# THE MAY SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

THE FUNGI OF BARRO COLORADO. PROFESSOR WILLIAM H. WESTON, JR. ..... 387
THE SCIENTIFIC WORK OF THE GOVERNMENT OF THE UNITED STATES:
THE ALASKAN WORK OF THE GEOLOGICAL SURVEY. CHIEF PHILIP S. SMITH ..... 408
ON THE RESEARCH WORK OF THE WEATHER BUREAU. DR. W. J. HUMPHREYS ..... 419
SCIENCE AIDS IN MOLDING BETTER LIVE STOCK. DR. JOHN R. MOHLER ..... 429
OTHERS. PROFESSOR ROSS AIKEN GORTNER ..... 435
LIQUIDATION AND REHABILITATION OF THE CONSUMER AND SMALL BUSINESS. PROFESSOR JOHN H. COVER ..... 444
SCIENCE SERVICE RADIO TALKS:
MINERAL RESOURCES, AN INTERNATIONAL RESPONSIBILITY. PROFESSOR RICHARD M. FIELD ..... 454
EARTHQUAKES—WHAT ARE THEY? PROFESSOR JAMES B. MACELWANE, S.J. ..... 457
HEALTH EXAMINATIONS AND CANCER. DR. FRANKLIN H. MARTIN ..... 460
SCIENCE AND GOVERNMENT. PROFESSOR HUGH S. TAYLOR ..... 463
THE FUNDAMENTAL UNITS OF THE PHYSICAL WORLD. PROFESSOR RUDOLF W. LADENBURG ..... 465
IS SCIENCE EXACT? FREDERICK H. LORING ..... 468
CONCERNING THREE-EYED FISHES. FRANK E. FIRTH ..... 472
THE PROGRESS OF SCIENCE:
*The Contributions of Professor Thomson to Electrical Engineering; The New Botany Building and Plant Houses of the University of Toronto; The Effect of Sunlight on the Growth of Flowers* ..... 474

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# THE SCIENTIFIC MONTHLY

MAY, 1933


## THE FUNGI OF BARRO COLORADO


By Dr. WILLIAM H. WESTON, JR.

LABORATORIES OF CRYPTOGAMIC BOTANY, HARVARD UNIVERSITY


In these days, when the demand for mouse-traps has appreciably declined and the trend of the public's purchasing is influenced chiefly by colossal advertising campaigns, there may be some doubt about the world making a path to that door where better mouse-traps are being manufactured. There is, however, no doubt at all that to the door of a biological station which offers unparalleled advantages in the rich field of tropical research, appreciative investigators will make their way in enthusiastic and ever-increasing numbers. Such a station is Barro Colorado, with comfortable and well-equipped laboratories most advantageously located at the edge of some six or so square miles of untouched tropical jungle, covering the irregular, wheel-shaped contour of Barro Colorado Island, as it lies in fortunate isolation surrounded by Gatun Lake, with the Bohio and Buena Vista Reaches of the Panama Canal and a stately traffic from the seven seas bounding it on two sides. And the path which has been worn to the door of the station is an easy five to seven days' travel from New York to Christobal by comfortable steamers, an hour of enjoyable train ride on the historic Panama Railroad to the little lakeside village of Frijoles, and an interesting and all too brief three miles by boat across Gatun Lake to the laboratory wharf. Is it not to be expected that biologists, naturalists and interested travelers should have come in growing numbers to this station, since through the energy and perseverance of a few far-sighted biologists, such as Thomas Barbour and James Zetek, it made its modest beginning seven years ago? Is it not wholly to be expected also that from those who have worked amid the unforgettable atmosphere and the unusual facilities and advantages of this station there should come numerous and diverse writings telling the world all about it? It is to be expected—even of scientific men.

As early as 1927, in his interesting Smithsonian Report on the Station, Professor Gross, of Bowdoin, listed a growing literature of over fifty titles relating to the island, and to this nearly double the number have since been added, until it can be said that they represent a varied list, from abstruse scientific papers read only by specialists, to articles with the deft popular touch and the excellent photographs that have universal appeal. As a result the island and the more interesting aspects of its plant and animal life are known not only to scientific men but to laymen as well, and if you are not as yet Barro Colorado conscious you have but to consult Dr. Chapman's delightful and informative "Tropical Air Castle" to know it at its best.

THE LABORATORY IN ITS CLEARING

AGAINST THE RISING WALL OF JUNGLE, DR. CHAPMAN'S "CASA MIA" AT THE LEFT, WITH A STOREHOUSE AND THE BANANA PLANTATION BELOW.

Yet in all this galaxy of literature little has been said of the fungi of Barro Colorado, and this is wholly natural, for in general appeal not even the deadly manchineel and the legendary upas tree, nor aristocratic and alluringly romantic orchids can hope to compete with sonorous howler monkeys or aloof nocturnal cats, with gaudy and clamorous toucans, superbly soaring vultures or colorful and cacophonous parrots. Much less can the humble fungi claim popular attention; they utter no haunting cries from the depths of the forest, nor do they flaunt flaming wings across your line of vision. Yet they are not without interest. Their remarkable diversity of form, structure and method of growth, their distribution in relation to different environments and to diverse substrata, their rapid and surprisingly efficient methods of development, their parasitism or saprophytism and their relation to plants, to animals, and even to man, commend them for a certain share of attention. Moreover, it should be remembered that without their activities this great cycle of jungle growth could not go on, since the whole vast machinery of plant life and of the animal life dependent upon it is prevented from being clogged with accumulated material by the activities of fungi in breaking down complex, elaborated substances into raw materials once more.

To one who is fortunate enough to live on the island, as I did, from October to May, it is apparent that there is a seasonal abundance and diversity of fungi directly related to moisture. During the rainy season from May through November when the great proportion of the more than 130 inches of rainfall occurs, winds are rare, and in the depths of the forest the air hangs breathless, saturated and still, so that fungi may grow in the dense tangle of jungle as undisturbed as they would in a greenhouse or a laboratory culture chamber, providing they are located where the direct downpour or the runlets and splashings of water can not strike them. It is surprising to one from a temperate climate to note, under the favorable conditions of this season, the abundant development of fungi on dead branches caught in the entangling creepers far overhead or on graceful palm leaves which, as they age, droop down and hang still fastened to the tree, or on whole tops of trees which, weakened by the tunnellings of termites and dragged down by their heavy burden of vines, have given way in some occasional storm and remain suspended above the ground, swung by the very strangling growths that have helped to cause their death. On such material the diversity of forms ranges from large, obvious, fleshy or woody fungi to the most delicate and evanescent moulds and Myxomycetes, which successfully form their exquisitely fragile sporophores in situations where the slightest jarring of the substratum shakes off a powdery shower of spores.

Out of the abundance and diversity of fungi developing during the rainy season certain groups and certain genera are so obvious as to strike the attention of even the casual passer-by along the trails, while others are to be discovered only after an intensive search guided by the experience or intuition of the trained collector. In general, it is in the order of their conspicuousness that fungi are collected in a new locality, and in the forest of Barro Colorado, just as in our own woodlands, it is chiefly the large, fleshy or woody Basidiomycetes and to a lesser degree some of the cup fungi and Pyrenomycetes that catch the eye. Among the Basidiomycetes the most obvious were chiefly the wood-destroying forms, both saprophytes and wound parasites; but the forms common with us, such as *Fomes annosus*, *Poly-*

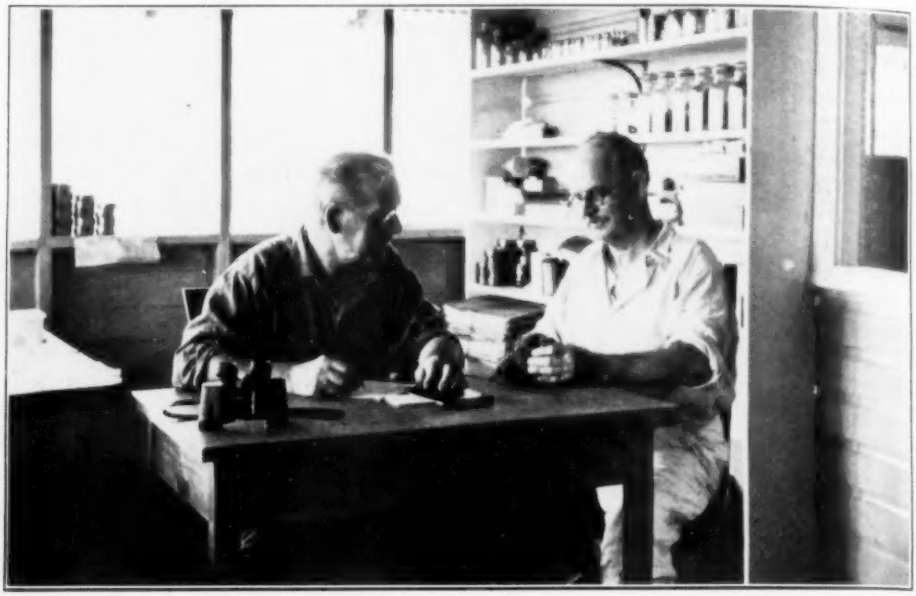
VIEW FROM THE LABORATORY

OVER THE SHELTERED INLET PAST THE WALL OF THE JUNGLE ACROSS THE BUENA VISTA REACH OF THE CANAL.

porus betulinus, *Polystictus versicolor*, and others, were lacking here, while, in contrast, representatives of certain related genera, rare or wholly lacking in our own country, were of common occurrence. *Hexagonias* (chiefly *H. tenuis* and *H. variegata*) were found growing on wood in abundance, their hexagonal pores in delicacy and regularity far surpassing biology's classic examples of six-sided construction, the cells of honeycomb; while delicate *Laschias* (*L. auriscalpium* and *L. Pezizoidea*), the smallest of the Polypores, usually rewarded an intensive search through débris of palm leaves. The usually ubiquitous *Schizophyllum* was rare here, and instead it was species of *Auricularia* that occurred everywhere, chiefly *Auricularia polytricha*, whose tough, rubbery little portes cochères, with their inconspicuous, brown, fuzzy tops, protruded from nearly every dead branch or twig not only in the moist shade near the ground but even high up near the forest roof, where I noticed it when I had climbed over 100 feet up in the great sand box tree renowned by Allee.

It was noticeable that the conspicuous fungi were chiefly those growing on wood, for in this tropical forest there is no autumn fall of leaves to carpet the ground and fill hollows and depressions with deep, matted, moisture-holding drifts ideal for the development of a mycelial network of fungous threads in the following summer. On the contrary, the highly individual deciduous trees of the jungle do not shed their leaves in unison but scatteringly, some at the start of the dry season, some later, some just before the rains begin again, and the scant deposits of leaves thus formed do not persist, so that the forest floor is typically rather bare. Perhaps for this reason the leaf-mould inhabiting mushrooms so common with us were few and infrequent and the picturesque motley of *Amanitas*, *Russulas*, *Lepiotas*, and the rest which enliven our New England woodlands was lacking on Barro Colorado, nor would a day's search be rewarded with a single *Boletus*, of which several species could be gathered in a square rod at home. Occasionally, groups of a most graceful agaric occurred on débris under the big trees, delicate specimens with black, slim stalks, hardly larger than coarse horsehair, yet as much as eight inches tall, supporting pallid dome-shaped caps less than an inch in diameter. Occasionally, also, groups of white infundibuliform sporophores of *Hypolyssus Montagnei* were seen, and associated with them a densely woven, felt-like, pallid mycelium which, starting from trash on the ground, grew upward on fallen branches or twigs or even on the stems of living shrubs and vines enveloping them in a conspicuous weft that faithfully followed every contour of their surface and even sent out delicate lace-like outgrowths of its own to add decorative embroidery to the whole.

Since it was chiefly on wood that the fleshy Basidiomycetes occurred, as might be expected, they were not limited to the woody trash of the forest, but occurred on lumber and structural timber as well. Bridges, railings and stairways along difficult trails and posts and sheds near the laboratory showed the destructive ravages of such fungi, which worked in effective cooperation with the termites, while near-by in the "experimental graveyard" in which sections of telegraph poles and other timbers, both untreated and treated with various preservatives, were kept to test their resistance to these destructive agents, wood-destroying fungi were found here and there, one small white agaric with a conspicuous bissoid base being especially noticeable. Even boats and skiffs of



THE SCREENED UPPER PORCH,

A COMFORTABLE LABORATORY, WHERE DR. FRANK CHAPMAN AND DALLAS LORE SHARPE DISCUSSED BIRDS.

selected hardwoods were not exempt, and it was through the ravages of an insidious *Poria* that the tough "roble" wood of "Tom," our faithful cayuca hewn from a single great log, was so weakened that in a rough sea one of the submerged stumps of the Drowned Forest could give it the gaping wound that caused its untimely end and forced "the botanist in his foolish forties" to cut his way home through a trailless part of the jungle, as has been so graphically described by Dallas Lore Sharpe.

Among the Basidiomycetes, the Gasteromycetes or puff balls, earth stars and allied forms apparently are not a conspicuous feature on the island. The crowds of puff balls commonly occurring in our own woods, on rotten logs or on the ground, were never seen there; instead, and only rarely, were found on rotten stumps the small, inconspicuous, buff-colored forms, apparently identical with Montaigne's *Geaster mirabilis*, which did not develop any pore, but finally, by an irregular breaking of the fragile wall, set free the stale-mustard colored spore mass within.

The Phallales, which, as their old and vulgar name of "stinkhorns" implies, are one group of Basidiomycetes that announce their presence to one's sense of smell as well as of sight, were represented on Barro Colorado by occasional examples of Clathrus and chiefly by a beautiful Dictyophora which was found here and there along the trails, its white, columnar, porous stalk, with the exquisitely fragile lace-work of the net for which it is named hanging from it, gleaming in contrast to the dark, soaked earth and sodden refuse from which it customarily developed. As in various other members of the family, the spores of this fungus were borne in a greenish, viscid mass on its expanded top, with an

odor decidedly attractive to insects. Yet flies, which usually seek such fungi and hence aid in dissemination, were never seen on these Barro Colorado Dictyophoras. Rather, both in the forest and while being photographed in front of the laboratory, all the specimens of Dictyophora were visited constantly by eager expeditions of ants, of a species of Pomerine ant which Professor Wheeler has kindly identified as *Ectatomma ruidum* Roger. No sooner was a specimen of this fungus set down than the ants began to arrive in considerable numbers, and in five minutes as many as thirty or forty would be clambering about the stalk or feeding on the spore mass and could easily be collected for identification. From the legs and mouth parts of ants secured while feeding thus, large numbers of the small rodlike spores with which they had become smeared were readily washed off into a drop of water and easily recognized under the microscope, so it seems probable these insects in their wanderings help disseminate the fungus.

Among the Ascomycetes certain of the cup-fungi were especially noticeable, the *Cookeinas*, so characteristic of the American tropics, occurring in such profusion along the trails, their stalked cups, a half inch to even almost two inches in diameter, standing out in such brilliant hues of salmon to vermilion against the dark forest floor that they never failed to catch the eye of passing biologists, even when engaged in such high quests as spying on the aerobatic courtship of red-headed manakins or timing the union working hours of leaf-cutter ants. Indeed, the two species of *Cookeina*, *C. sulcipes* (Berk.) Kuntze and *C. tricholoma* (Mont.) Kuntze, enjoyed the rare distinction of being the only fungi of Barro Colorado that visit-

THE FOREST FLOOR

RELATIVELY FREE FROM MUSHROOM-GROWING LITTER, AS THERE WAS NO AUTUMNAL FALL OF LEAVES.

CROSSING GATUN LAKE

IN THE OUTBOARD MOTOR BOAT FROM FRIJOLES, THE CARETAKER, DONATO, AT THE HELM; BEHIND, A DUGOUT LOADED WITH SUPPLIES.

ing ladies with a flair for painting china yearned to immortalize in the undying pigments of their art.

Perhaps second to the colorful *Cookeinas* in conspicuousness should be ranked the dark *Xylarias*, which were represented on the island not by the two or three forms common with us but by an abundance of species, some with elaborate, dichotomously branching fruiting bodies, others with the single perithecial columns variously club-shaped, of diverse sizes, showing lineate or reticulate markings or perhaps with a crown of protrusions at the apex and some densely clustered in irregularly sprawling groups. Also noticeable were the *Camilleas*, protruding like small, black, gleaming trench mortars from fallen wood, while commonly through the forest, dead branches or logs were marked with the dark stromatic perithecial cushions of *Nummularia* and *Hypoxylon* or bristled with the hard, black, pinhead clusters of *Phylacia* or *Kretzschmaria*. Occasionally also the minute, orange perithecia of *Corallomyces* or *Nectria*, representatives of the related though more colorful Hypocreales, caught the eye.

A WOOD-DESTROYING BRACKET FUNGUS OF SOFT TEXTURE, ONE OF THE FEW FUNGI OF THE ISLAND EATEN WITH RELISH BY THE PET MARMOSET MONKEYS.

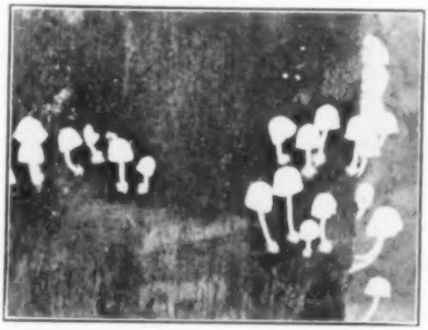
CONSPICUOUS FUNGI ON DEAD WOOD HERE WERE COMMONLY SPECIES OF *Hexagonia*.

The Phycomycetes, the delicate, thread-like and inconspicuous moulds which at home attract our attention chiefly through the unwelcome growth of bread-mould in pantries and bread boxes, are never an obvious feature in the fungous flora of any tropical region, save, perhaps, as the result of their activities shown in gaunt, skeleton groves of coconut trees killed by bud-rot and blasted acres of stunted maize devastated by downy mildews. Yet on Barro Colorado, with a little search one

could find here and there occasional representatives of this interesting group: Bristling fringes of *Choanephora*, with threadlike, metallic-glinting stalks and dark, spore-powdered heads revealed in the morning light on the fallen, dew-drenched hibiscus blossoms where they had developed during the darkness; occasional delicate tufts of *Mucor* on caterpillar droppings or of *Rhizopus* on fallen flowers and fruits along the trail; incredibly slender, upright threads of

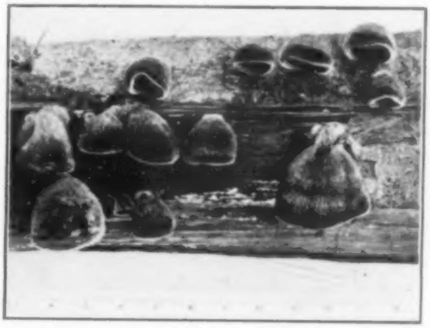
*Dictyophora duplicata*, THE CONSPICUOUS WHITE "STINK HORN" WITH ONLY FRAGMENTS OF ITS HANGING "LAMP MANTLE" NET REMAINING.

*Phycomyces*, shining silver in the dark forest on dung of some member of the cat tribe or on bits of flesh clinging to the bones of some animal's kill; short, stubbly, pinhead growths of *Pilobolus* on tapir dung in remote tapir wallows in deep and isolated ravines; or an exquisite white lacework of that new genus, *Lymania*, gleaming against dark piles of débris which many years of occupancy by unlovely bevies of bats had left in the cavernous base of a great hollow tree.

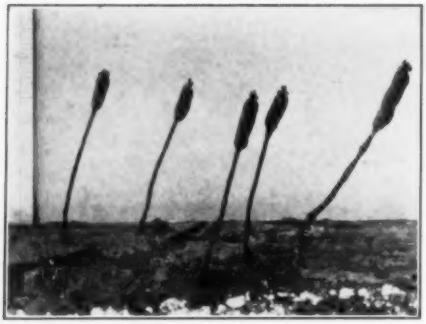


A WHITE AGARIC HELPING IN THE DESTRUCTION OF TERMITE-TUNNELED WOOD SAMPLES IN THE "EXPERIMENTAL GRAVEYARD."

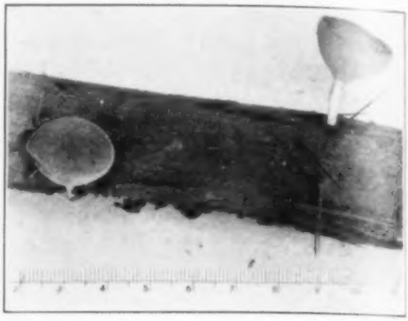
The Myxomycetes or "slime-moulds," almost as inconspicuous as the Phycomycetes, yet more widely advertised because of their extraordinary life cycle and perplexing affinities with both plant and animal phyla, were fairly common on Barro Colorado. One of the most noticeable species, because of the whiteness and extent of its tufted turf of sporophores, was *Ceratiomyxa fruticulosa*, which occurred not only on fallen wood, as with us, but also on dead branches lodged or suspended in the air where the least disturbance shook off a powder of spores from the extremely fragile, externally spore-bearing fructifications which mark this genus as unique among the Myxomycetes. Also *Lycogala epidendrum* attracted atten-



*Auricularia polytricha*, COMMONLY FOUND ON DEAD WOOD EVERYWHERE THROUGH THE FOREST.



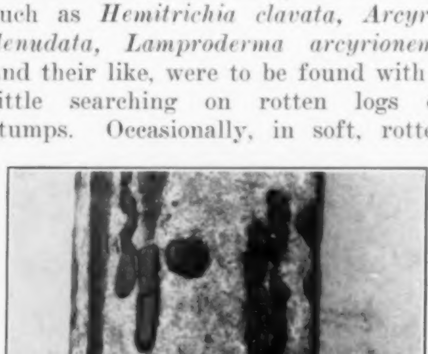
*Xylaria comosa,* BEARING A CROWN OF PROTUBERANCES ABOVE THE PERITHECIAL COLUMN.



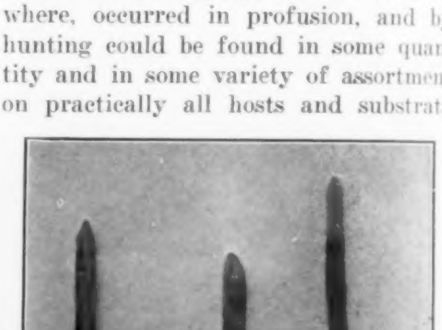
*Cookeina sulcipes,* ONE OF THE CUP FUNGI WHICH DOT THE FOREST FLOOR WITH BRILLIANT SPLASHES OF COLOR.

tion, because of the relatively large size of its clustered, puff-ball-like sporangia; *Hemitrichia serpula,* because of the unusual serpentine labyrinths of its plasmodiocarps; and *Fuligo* and *Brefeldia,* because of the extent of their crusted and crumbling aethalia. Moreover, along the trails and deep in the forest common though less conspicuous forms, such as *Hemitrichia clavata, Arcyria denudata, Lamproderma arcyrionema* and their like, were to be found with a little searching on rotten logs or stumps. Occasionally, in soft, rotten wood or dead leaves were encountered the creeping, feeding, protoplasmic plasmodial stages of these organisms, one of which, when brought to the laboratory, successfully developed the clustered sporangia of the fruiting stage of *Didymium squamulosum.*

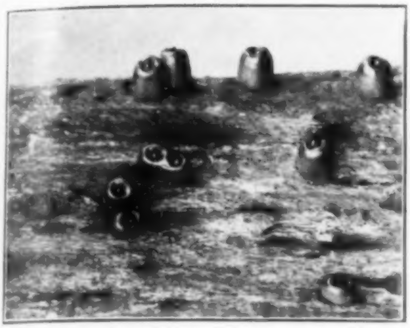
The *Fungi Imperfecti,* here as elsewhere, occurred in profusion, and by hunting could be found in some quantity and in some variety of assortment on practically all hosts and substrata



*Hypoxylon Merillii,* A COMMON PYRENOMYCETE ON DEAD WOOD ALONG THE TRAIL.



*Xylaria grammica,* THE MOST CONSPICUOUS OF THE *Xylarias,* WITH COLUMNS AS MUCH AS SIX INCHES TALL.



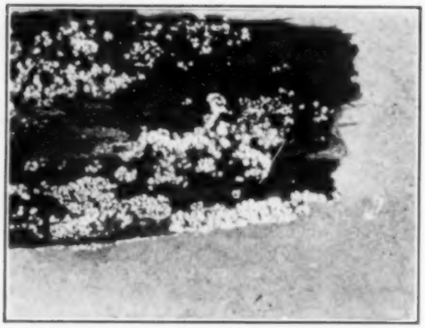
*Camillea mucronata,* WHOSE GLEAMING BLACK COLUMNS PROTRUDED LIKE SMALL TRENCH MORTARS FROM WEATHERED LOGS.

*Phylacias* SUCH AS *P. poculiformis* WERE COMMONLY ENCOUNTERED.

imaginable at all times. The parasitic forms of course were common, for Barro Colorado, although an island paradise, probably harbors as many parasites, although fortunately of a different category, as does New York or Chicago. Moreover, some as secondary invaders followed the tunneling of leaf-mining insects in leaves of a wide variety of hosts; while many as well were saprophytic on rotting stems and branches, not only old friends familiar in New England, such as the green and velvety *Trichoderma lignorum,* but also rare and beautiful new species of *Rhinotrichum* and similar wood-inhabiting genera. Save in rare instances, however, the *Fungi Imperfecti,* here as elsewhere, do not occur in the open in sufficient profusion to attract immediate attention. There is one, however, which here, as in other parts of the tropics, is a striking exception. This mould, *Monilia crassa,* the imperfect stage of

*Hypoxylons* SUCH AS THIS (*H. Broomeianum*) REWARDED THE COLLECTOR EVEN DURING THE DRY SEASON.

MANY MYXOMYCETES SUCH AS *Lycogala epidendrum,* COMMON IN OUR OWN WOODS, GAVE AN ASPECT OF FAMILIARITY TO THE BARRO COLORADO FOREST.



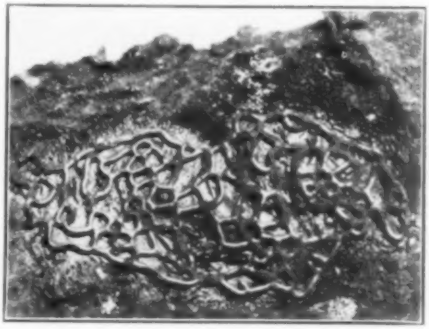
OF THE MYXOMYCETES, *Ceratiomyxa fruticulosa*, ALTHOUGH ONE OF THE MOST DELICATE, WAS FREQUENTLY FOUND.

the Ascomycete *Neurospora crassa*, appeared in a strip along the shore where the jungle had been burned off during the dry season to make a clearing for growing bananas. From the scorched wood of charred stumps and blackened branches over this area there appeared overnight great masses of salmon pink tufts of mould, from which powdery clouds of spores were scattered through the air at every puff of wind or jarring touch. This same striking phenomenon I have seen in Cuba in burned clearings or on sugar-cane after cane fires, and it is reported that a similar profuse growth developed on burned trees in Japan after the Tokyo earthquake and fire and on the forest trees that had been scorched by volcanic eruptions in Java.

It is in the laboratory, however, that such moulds force themselves on one's attention, for in the rainy season conditions are ideal for the growth of many species of such prevalent genera as *Aspergillus*, *Penicillium*, *Alternaria*, *Cladosporium*, especially on leather, on textiles and on composition fabrics. On leather cases, on shoes, on sweatbands of hats, on paste-impregnated bindings, on all kinds of cardboard, powdery discolorations and even bristling growths of mould appeared with magical rapidity.

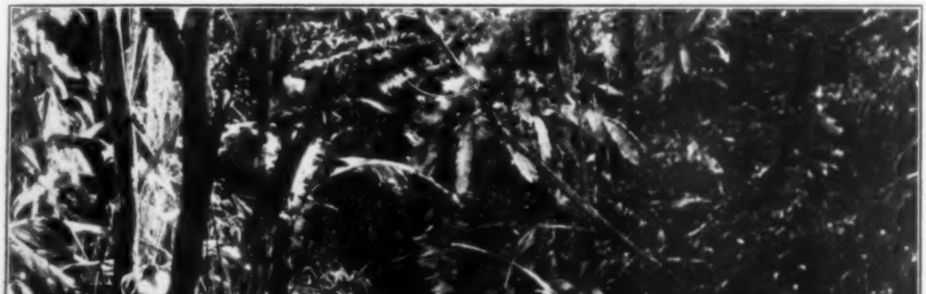
SHADED LAGOONS FAVORABLE FOR COLLECTING DURING THE DRY SEASON WERE ACCESSIBLE IN THE FAITHFUL CAYUCA, "TOM."

even in some cases over night. Great care had to be taken to prevent collections of dried plants or insects from being ruined thus, and even specimens in such preservatives as alcohol and glycerine were not immune from similar injury. Also it required reasonable care to protect the lenses of cameras and other instruments from the development of minute, delicate traceries of mould which, if allowed to grow undisturbed, in time would actually etch and injure the perfectly polished surface of such valuable glasses; nor could film be left too long unrolled in the camera for fear of unexpected mycelial patches lending a bizarre appearance to the resulting pictures. Even permanent masonry buildings, more protective than our laboratory, were not exempt from similar mould infestation, for during that same season Canal Zone officials were being annoyed by growths of mould which, quite without respect for art, architecture or governmental authority, were disfiguring Van Ingen's interesting and impressive murals in the Government Building at Balboa.



THE CONSPICUOUS SERPENTINE NETWORK OF *Hemitrichia serpula* OCCASIONALLY ATTRACTED THE ATTENTION OF THE PASSER-BY.

On Barro Colorado, as in other tropical places, there is one group of fungi for which one does not have to seek—on the contrary, in diverse and devious ways, they themselves find their way to you, much to your discomfort and regret. These are the obscure fungi which



BROOK BEDS LURED THE COLLECTOR WHEN THE UPLANDS WERE DRY.

parasitize man and hence occupy a place of importance in a fascinating border land of investigation between medicine and mycology. Occasionally, on the chafed, perspiration-soaked skin, despite the daily shower baths that the excellent bathing facilities of the laboratory made possible, there appeared small eruptions of "Dhobie itch," easily cured, and of interest chiefly because of the name which, despite what the marines will tell you, is not derived from "doughboy," and, in spite of what those along the Mexican border aver, is in no way connected with "adobe," but rather, as you probably know from books about India, is derived from a native name of the washerman or washerwoman, because the germs of this fungus may survive and be transmitted by the native methods of washing clothes in the water of ditches or streams and spreading them on the grass to dry.

MOULDS FLOURISHED ON LEATHER CASES IN THE SATURATED ATMOSPHERE OF THE RAINY SEASON.

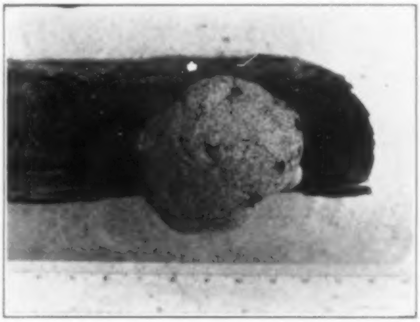
SALMON PINK SPORE PUSTULES OF *Monilia crassa* STOOD OUT BRILLIANTLY AGAINST SCORCHED STUMPS AND BRANCHES IN THE FRESHLY BURNED CLEARING.

Now and then also itching and even painful cracking between the toes gave evidence that the fungus infection known to the magazine reading public as "athlete's foot" is by no means confined to bridge-playing debutantes or rising young brokers whose exercise, according to the advertisements, consists in reaching for a cigarette, or climbing into a Rolls Royce, but attacks the humble and hard working biologist as well. After vainly attempting a cure with the greenly fragrant modified horse liniment press-proclaimed as specific, the harassed victims successfully overcame the trouble with Whitfield's ointment or other like compounds found effective by reputable dermatologists and rendered up thanks that only these relatively mild fungous afflictions are known to the island and not such medico-mycological horrors as Madura foot, blastomycosis or sprue.

As the rains lessen and become infrequent in late November and early December, and by January and February the dry season is well advanced, striking changes are noticeable in the fungous population of Barro Colorado, for although "What Men Live By" may require exposition in books and essays so numerous as to indicate some difference of opinion, it is in general a certainty that what fungi live by is warmth, food and, above all, moisture. With the advance of the dry season fungi become less conspicuous, yet Barro

Colorado still offers opportunities to the mycologist, for in deep brook beds, along the edge of the lake, and in the numerous shaded lagoons of long-drowned gullies, the proximity to moisture prolongs the growing season of certain fungi, while in the lake itself that fascinating group of the aquatic Phycomycetes continues to flourish, even though the water may reach a temperature of 85°, and logs or matted islands of vegetation floating on the surface may support fungous growth unchecked by the general drought of the inland slopes. Also at the height of the dry season hardy, slow-growing Pyrenomycetes still persist, and fallen remnants of succulent flowers or fruits which mark the burgeoning of the drier months may furnish a temporary moisture to support the brief periods of growth of delicate, evanescent moulds. Even during the dry season, however, a few inches of rain fall in occasional showers, which bring about remarkable changes in some of the persistent xerophytic Auriculariales or jelly fungi. These, dried to hardened, cartilaginous, inconspicuous layers or nodules, rapidly take up moisture and appear as if by magic as rubbery or gelatinous fungous growths, easily seen by the passer-by.

Having noted that of the three prime requisites for fungous development—warmth, food and moisture—it is moisture which on Barro Colorado is chiefly the limiting factor, it is worth mentioning, perhaps, that there are some rather interesting limitations to definite food supply and definite substrata. Most of the fungi encountered, of course, are catholic in their tastes, occurring on almost any forest refuse, woody or soft, but some were definitely restricted to certain substrata and never found under any conditions on any other material. For example, the common occurrence of *Xylaria ianthino-velutina* Mont. on the fallen pods of *Apeiba aspera*, which lie like misplaced sea urchins on the forest floor, was notable, for this species of *Xylaria* was never found on any other substratum. Also a brilliant cinnabar and golden colored agaric, found commonly on recently fallen pods of *Bombax barigon* in January, was never seen on anything else nor even on these pods after they dried and shriveled later in the season. Then, too, the tall, dark,



*Entonaema mesenterica* COULD STILL BE FOUND DURING THE DRY SEASON.

*Phillipsia Domingensis*, ITS BUFF CUP LINED WITH CRIMSON, WAS A LUCKY FIND IN A DEEP RAVINE DURING THE DRY SEASON.

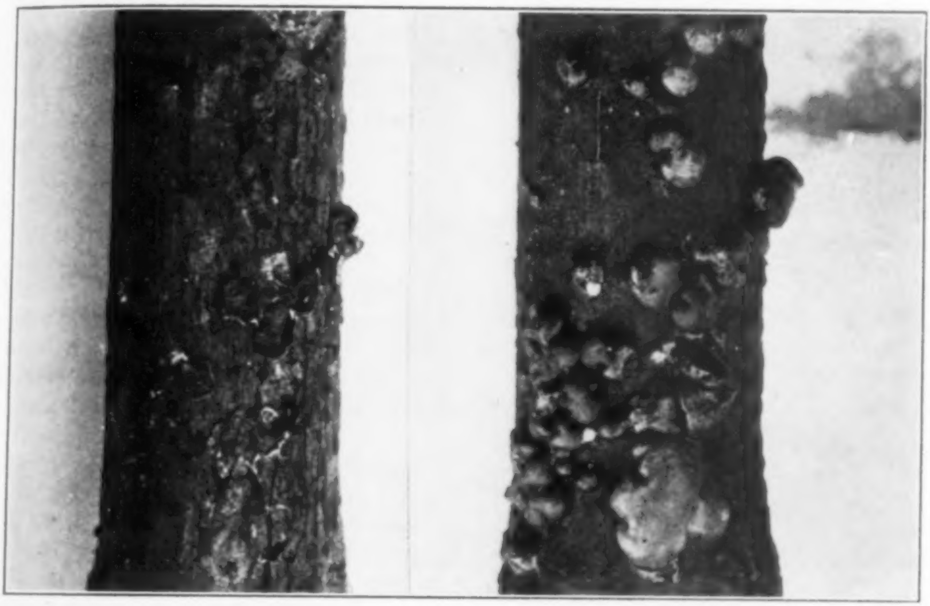
HARDY *Auricularias* ENDURING THE DRY SEASON (LEFT), EXPANDED RAPIDLY AFTER SHOWERS (RIGHT).

*Auricularia mesenterica* BEFORE AND AFTER A SHOWER, SHOWING THE FANCIED RESEMBLANCE TO AN EAR THAT HAS LED TO ITS COMMON NAME "OREJAS."

fuzzy parasols of *Lentinus velutinus* Fr., seemingly sprouting from the earth along the trails, were invariably found to originate from small, hard, knotty pieces of heart wood, the persistent remains of branches otherwise disintegrated, long buried in the soil.

With so numerous an insect fauna on the island and so many fungi, one can encounter many instances of the interesting interrelations between these two fascinating groups of organisms, and it is to be regretted that this intriguing field of investigation has not been pursued further on the island. Wherever the nests of leaf-cutting ants were cut open, the curious, knobby fungous growth that is cultivated by the Attas could be found, while the trails of leaf-mining insects and galleries of wood-tunneling termites gave evidences of interesting fungous associations. Occasionally, also, on the wild pineapples (*Ananas magdalense*), which in the low ground of the forest form dense thickets of fish-hook spined leaves, specimens of Septobasidium were found near the tips of somewhat *passé* leaves. This was apparently a new species of this interesting genus, awaiting the attention of Couch, whose work has brought out the beautiful interrelationship of this fungus and the scale insects associated with it.

The growth of certain fungi on insects as parasites is perhaps a less conspicuous feature here than in temperate regions, for, although entomogenous fungi were sought on Barro Colorado, very few were found. In one case I encountered a small cockroach covered with a pale, gray-green, powdery growth of *Metarrhizium*, while Curran, during his collecting of *Diptera* and other insects, gathered in not only further examples of this green muscardine fungus but also an *Isaria* on two small bugs and a beautiful, slender, though immature *Cordiceps* on a beetle. The Entomophthoraceae, although sought par-



JELLY FUNGI, INCONSPICUOUS WHEN DRY, APPEARED AS IF BY MAGIC AFTER OCCASIONAL SHOWERS.

ONLY ON THE FALLEN PODS OF *Bombax barigon* WAS THIS GOLDEN AND ORANGE AGARIC FOUND.

ticularly, either were rare or else escaped intensive search, for I found no specimens nor did Curran, even though

SUCH ENTOMOGENOUS FUNGI AS *Metarrhizium* WERE SELDOM ENCOUNTERED.

he intensively collected hundreds of *Diptera*, which in temperate regions are relatively common hosts for these parasites.

In tropical regions such as this with abundant fungous flora comprising many conspicuous noticeable members, it is always of interest to learn to what extent the observant though not scientifically trained people of the vicinity recognize fungi by vernacular names or make use of them in food, medicine or industries. In general, here on the island, as elsewhere in the vicinity, one encounters only a scanty vocabulary of vernacular names. Men of some education, such as Donato, the versatile and indispensable caretaker, knew the Spanish word "hongo" for fungi as a whole, but lacked names for the many very different types; while uneducated workmen did not have any distinguishing vernacular names for fungi in general, much less an assortment of different words for different kinds. The only common word in general use seemed to be "orejas" or "orejas de palos pudridos," merely the Spanish for "ears" or "ears of rotten stumps." This Spanish name "orejas" is of some interest, as it is based on a resemblance which has led to a number of similar names in various languages. Here it seems to be applied particularly to the gelatinous *Auricularia*, the common name of which in English is "Jew's ear" or "Judas' ear" fungus, the same root to which the scientific name of the species, genus and family gives formal Latinized recognition. For the *Auricularia mesenterica* common on Barro Colorado, with its general shape of the human ear, its elastic, cartilaginous texture, veined or folded surface, and warm brown color, this is indeed an apt characterization. The term is not restricted to this type of fungus, however, but is used for Hymenomycetes in general, whether

smooth or with gills or pores, sometimes followed by a qualifying adjective such as "blanco" or "grande." It is interesting that with much the same appreciation of this resemblance some of the natives of the Philippines call such fungi "oong," meaning "ear," while in other languages of Malay origin like words of similar meaning are used. In Cuba also such fungi quite generally are called "orejas," but in addition the Guajiros or country people employ the word "guataca," which merits further explanation. The "guataca," strictly speaking, is the heavy hoe used for digging out grass or other weeds from fields of cane or corn, and, being a typical and indispensable instrument of the Guajiros, enters into their slang or argot in that a person with large and prominent ears is said to have "guatacas," which is equivalent to the phrase "shovel ears," which one occasionally hears in our own South; while flattering or otherwise working a person to obtain something is usually called "guataqueria," literally "hoeing," which offers an amusing similarity to our sophisticated phrase "gold digging."

In contrast to the scarcity of names used for fungi by the people of the Barro Colorado region, there is a long list of colloquial names applied to flowering plants of the locality, some of them strikingly picturesque, clever and colorful. Indeed, the same aptness for simile led to the immediate invention of equally vivid names for fungi, when these were called to the attention of the natives. For example, when shown Dictyophora, with its white lace-like net, they immediately called it "hongo de camiseta" or "hongo de camiseta de lamparillo," literally "lamp mantle fungus," deftly expressing the resemblance which the delicate, hanging veil bears to the common Welsbach gas mantle. Nor were they slow to invent in Spanish or vernacular aptly characterizing names of untranslatably obscene significance, which certain resemblances of the Phallales have evoked in various languages since the most ancient times.

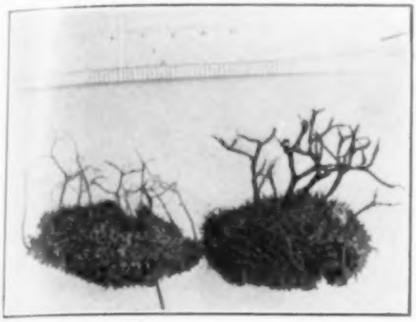
The small recognition of fungi in vernacular names is paralleled by the scanty notice which they receive in other respects throughout the region. Apparently they are never used for dyeing, tanning or tinder, seldom eaten, and

A SLENDER *Cordiceps* ARISING FROM THE DEAD BODY OF ITS BEETLE VICTIM.

little used in medicine, although I was told that in the interior further back from the Canal Zone the people, in a rude practice of first aid, frequently use a fungus, which from the description is apparently a puff ball, applying the mass of spongy tissue and spores to a cut to "make the blood stick," as they say, a practical use for such fungi by no means limited to Central America, but once common in England and Europe and even now occasionally followed in our own rural regions.

From the very nature of fungi there is less perhaps of romance and danger in their collection than in seeking wild animals or orchids, yet even in collecting fungi in this tropical jungle environment of Barro Colorado there are moments of excitement. Once, for example, when reaching down to secure an unusually luxuriant growth of *Xylaria consociata* Starb. on a rotten log, I was checked by an exclamation from my companion, Dr. Dunn, who pulled out the trusty Game-Getter gun and shot a six-inch tarantula which lurked, black, hairy and dangerous, poised in an almost perfect concealment among the black sprawling fungus growth a few inches beyond the specimen toward which I was reaching. There were also instants not without hazard in collecting along the coast line of the island in a small and delicately balanced cayuca, for the high waves, which during the dry season were soon piled up by the wind blowing steadily across the broad stretches of the lake, not only in themselves rendered navigation in a dugout exciting to say the least, but when augmented by the wake of large steamers passing close by required quick and strenuous work to keep from being overturned. These same waves from passing steamers produced one unexpected effect, for as they rushed into some of the narrowing inlets so located as to receive their full force directly, their power increased as the inlets narrowed until in the little muddy brook beds at the end of such inlets, small tidal waves as much as two feet high would come rushing onward carrying everything before them. These proved a great surprise to an unwary investigator who, standing in an apparently dry brook bed with material scattered about and a camera set up, would suddenly, without warning, find a rush of waves bearing down upon him to swamp everything

STUMPS OF THE DROWNED FOREST, HERE REVEALED BY LOW WATER, MADE NAVIGATION IN A DUGOUT HAZARDOUS.



SEA URCHIN-LIKE PODS OF *Apeiba aspera*, THE ONLY SUBSTRATUM ON WHICH *Xylaria ianthino-velutina* WAS FOUND ON BARRO COLORADO.

THE TOUGH, VELVETY PARASOLS OF *Lentinus velutinus* ALONG THE TRAIL INVARIABLY AROSE FROM HARD, KNOTTY REMNANTS OF BURIED BRANCHES.

and leave him grabbing frantically to rescue the well-soaked relics which otherwise they would have carried away.

It can be seen that the island is a rich collecting place for the mycologist, for the fungi on which this brief and fragmentary account is based were encountered only incidentally, since I was engaged in the study of a small, specialized group of submerged aquatic Phycomycetes and did no intensive collecting of other groups, merely picking up what I encountered in tramping the trails or exploring the inlets and gullies around the island shore. Such an account as this, therefore, is in no sense a representative record of the fungi of the island. It touches not at all on the innumerable leaf-spotting forms or the sooty moulds that occur with such frequency that one leaf has been said to furnish some of our colleagues with enough material for one monograph, two students' doctorate theses and four short papers. It neglects equally the smuts and rusts, it ignores the innumerable manifestations of fungous associations with algae in the brilliant and many-formed lichens in which the jungle abounds, but, although scanty, it may serve to give to others some idea of the abundance and interest of the fungi which await further study in this untouched island paradise for biological investigation.

MOUNT McKINLEY, ALASKA

THE HIGHEST OF THE MOUNTAINS ON THE NORTH AMERICAN CONTINENT, 20,300 FEET.

# The Scientific Work of the Government of the United States

## THE ALASKAN WORK OF THE UNITED STATES GEOLOGICAL SURVEY

By PHILIP S. SMITH

CHIEF ALASKAN GEOLOGIST, U. S. GEOLOGICAL SURVEY

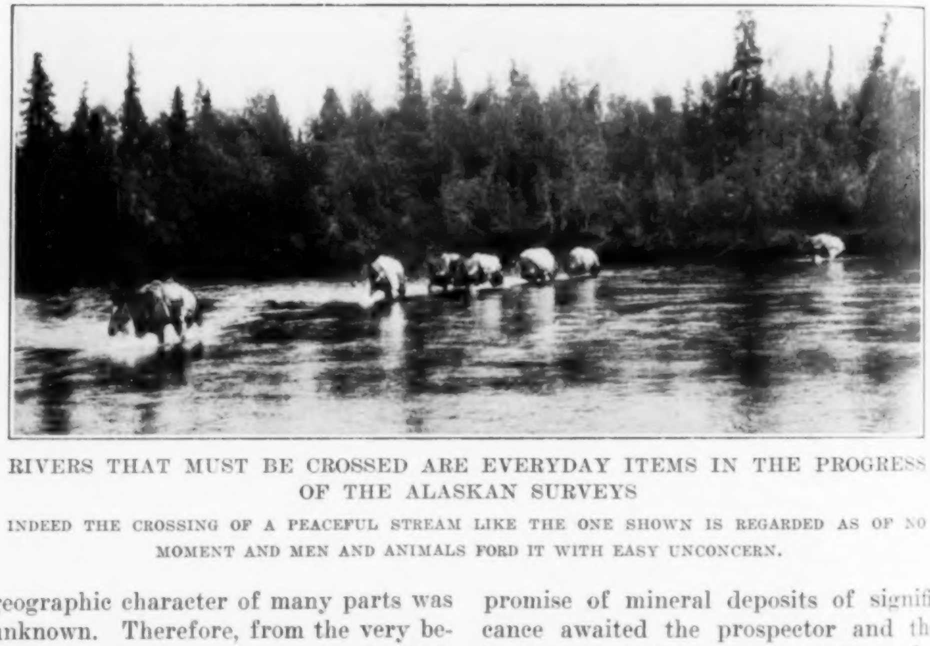
WHEN Alaska came into the possession of the United States through purchase in 1867 it was an almost unknown country whose resources were thought to consist mainly of wild animals and untenanted land. As time went on other sources of wealth were found in it and exploited. Most of these finds were more or less intimately involved with geographic problems or with mineral resources, so that the United States Geological Survey early became officially concerned with Alaskan developments, though notable contributions to knowledge of the country were made by many other government organizations, such as the War Department, Navy Department, Bureau of the Census and Revenue Cutter Service, as well as by many private organizations and individuals.

As early as 1889 one of the members of the Geological Survey, attached to an expedition of the Coast and Geodetic Survey, traversed much of the Yukon from the mouth upstream and thence went overland to the coast at Dyea. In 1890 and 1891 one of the Survey geologists made extensive explorations in the vicinity of Mount St. Elias and almost reached the top of that 18,000-foot giant. In 1891 another of its members made a notable trip through the unexplored country inland from Juneau and thence by a devious route to the Copper River, and several extensive contributions to knowledge about Alaska were made by other members, either as part of their official duties or when attached to other enterprises.

The discovery of the fabulously rich gold fields of the Canadian Klondike and the impetus that that discovery gave to the gold seekers to extend their search into adjacent parts of Alaska resulted in 1898 in the Geological Survey making special efforts to supply reliable information to these pioneers, through sending out numerous field parties of its own and through collating and publishing the available information accumulated by others bearing on Alaskan matters falling within its field of endeavor.

This marked the real beginning of a distinct Alaskan organization as a unit of the Geological Survey, though administratively it was not officially designated as a separate entity until 1903, and it was not formally recognized as a major subdivision of the Geological Survey equivalent in rank with the other major branches, such as those dealing with geology, topography and water resources, until 1922.

The principal object of this unit, as tersely stated in the appropriation item by which funds for its support are granted by Congress, is "investigation of the mineral resources of Alaska." This, then, has been the prime aim of its endeavors and the focus of its studies, but the pursuit of this aim has involved many contributory undertakings that may not at first thought seem related to the major problem. When the work was started much of Alaska remote from the coast and from the main highways of travel—the large rivers of the interior—was so little traversed that even the



RIVERS THAT MUST BE CROSSED ARE EVERYDAY ITEMS IN THE PROGRESS OF THE ALASKAN SURVEYS

INDEED THE CROSSING OF A PEACEFUL STREAM LIKE THE ONE SHOWN IS REGARDED AS OF NO MOMENT AND MEN AND ANIMALS FORD IT WITH EASY UNCONCERN.

geographic character of many parts was unknown. Therefore, from the very beginning a pertinent part of the Geological Survey's job was the determination of the most suitable routes to the reported gold strikes and the furnishing of general information as to the conditions that prevailed there. Vast areas were entirely unexplored, so that determination as to whether or not they held promise of mineral deposits of significance awaited the prospector and the investigation of the Survey. Even for the best-known areas the available maps were usually so crude and inaccurate that few of them were reliable guides for the prospector, and practically none of them were suitable bases for use in the field investigations of the known mineral deposits. Therefore, as an in-

dispensable part of its work on mineral resources, the Alaskan unit began the topographic and geologic mapping of the Territory. In the more settled regions of the States the topographic map is to be used for many engineering purposes and is therefore made on a fairly large scale, but in Alaska, in the interests of economy and to meet only the most pressing needs, the mapping was done principally on an exploratory scale (8 miles to the inch or smaller) or a reconnaissance scale (4 miles to the inch). As a result of the surveys that have been made by the Geological Survey during the last 35 years, more than 260,000 square miles has been surveyed geologically and 277,000 square miles has been surveyed topographically. These areas represent respectively about 44 per cent. and 47 per cent. of the 586,400 square miles embraced within the territory. Much less than 1 per cent. has been surveyed even to date on as large a scale as a mile to the inch, the usual detailed scale adopted for comparable work in the states proper.

In making these surveys the government geologists, topographers, and engineers have necessarily had to conduct their work so as to fit the field conditions encountered. Thus many of the parties have covered the areas assigned for their investigations by the use of pack trains, consisting of as many as a score of animals loaded with the equipment and supplies required for months of traveling away from all centers of replenishment. Others have traversed thousands of miles of streams and hundreds of miles along the coasts in fragile canoes, skiffs, poling boats or other river craft. Others, especially those working in southeastern Alaska, have carried on their surveys from power launches that not only served as the means of transportation but also afforded shelter and home to the parties in the field. Still others have used dogs extensively for the transportation of their supplies—in the winter driving them attached to the freight sleds, in the summer hitching them to the tow-lines of the boats to help haul on the upstream journey or loading their backs with packs for cross-country travel. In fact, practically all means of transportation, from the swift-flying airplane to the slow, laborious plodding of man with a heavy pack of supplies and equipment on his back, have at different times and on different expeditions been used by the Survey's explorers as they have wrested the knowledge of the far-off parts of Alaska and acquired the data from which their maps and reports have been constructed. Throughout thousands of miles the trails and routes of these explorers are still the basis for the only definitely recorded annals of the country, though doubtless others who have left no trace of their travels and discoveries have also visited some of the remote regions.

Working under such conditions, the members of the field force of the Alaskan branch must necessarily be all-round outdoor men. Familiarity with field conditions and capacity for personally undertaking the accomplishment of their technical work under whatever conditions they may encounter are taken as much for granted as that the ordinary citizen will be able to find his way around his home town. It is the proud boast of the Alaskan branch that in spite of the hazards its men have faced and overcome, none of its parties has ever lost a man or had one permanently injured. To paraphrase a combination of advertising slogans, "They get there and bring back results."

This sort of pioneering, however, is only one phase of the Geological Survey's investigations, and in a way it may be likened to a preliminary sorting by which the more promising areas for further study are separated from those that do not appear to have resources that require such immediate attention. In other words, as a result of these pre-

TRANSPORTING EQUIPMENT

WHEN ALL OTHER MEANS OF TRANSPORTATION PROVE IMPRACTICABLE THE MEMBERS OF THE ALASKAN PARTIES MUST PACK ON THEIR OWN BACKS ALL EQUIPMENT AND SUPPLIES NEEDED TO PUT THROUGH THE WORK.

liminary explorations the geologist attempts to discriminate areas of moderate extent that appear most likely to contain mineral deposits of value. How is this determination made? There is no royal road to the answer. It involves the application of every phase of geologic science, and ability to make it can be acquired only by long and thorough training and wide familiarity with the various types of mineral deposits throughout the world and the conditions that contributed to their formation. Coupled with that knowledge must be keen observation of all the features in the region that is being studied, so as to appreciate similarities to favorable localities or differences that may be of significance. The Alaskan geologist must be always alert to grasp the facts, so that he is not hesitant in adopting new views nor yet hasty in embracing the novel simply because it is new. A sane balance and a reliance on carefully weighed evidence are obviously indispensable in arriving at a sound judgment. Nor is a judgment once reached necessarily final, because each new advance in science and each new development yields new criteria and new data by which old judgments must be retested and, if necessary, revised.

To adapt the old saying "Physician, heal thyself" to this problem, it is evident that before the geologist can be of much help in suggesting where new mineral deposits may be found he must be well acquainted with the region about which he is to venture a prediction. He must, therefore, have scrutinized with especial care all its mines and the places in it where signs of valuable minerals have been found, so as to become thoroughly familiar with every fact bearing on the conditions under which the deposits occur. He is then in a position to formulate his ideas as to the places where extensions of those conditions are likely to be found and can thus direct his search toward testing the accuracy of these ideas and, if they successfully stand that test, make them known to the public he aims to serve.

However, these investigations are not limited to studies in the field, for the collections of rocks and minerals and the voluminous notes and records must be subjected to further studies in the laboratory, and the literature on related subjects must be examined and balanced against the observations in hand. This work may involve chemical analyses or microscopic tests of the ores, critical diagnosis of the fossils, and perfecting of the field sketches, maps, and notes; in fact, every line of research is utilized that may contribute to a more accurate and thorough comprehension of the problems involved and to the working out of their answers. As a result, more time is usually required for the digesting and putting into order for publication these records of observation than for their original collection in the field.

Although all the Alaskan work is

focused on the investigation of the mineral resources of the territory, the items that contribute to that subject are diverse, and many of the by-products of these studies are of significance. Whatever pertinent information can be obtained from other sources is of course utilized, but in the progress of the Geological Survey's own studies in remote and unexplored districts much general information not otherwise available is obtained, relating, for example, to various climatic elements, such as rainfall and temperature, or to the distribution of timber that might be utilized in mining, or to the native animals that might be used for supplying food. Some of the technical by-products of these studies which may not be directly connected with the prime object of the investigations are the recognition of some of the special geologic processes that are active in higher latitudes than those with which most geologists are familiar; the collection of fossils that furnish an insight as to many of the conditions that prevailed in the region when they were parts of living organisms; and evidences of past glaciation that smothered large tracts in northern United States and in part affected Alaska also. In fact, the general information obtained by the Alaskan field force covers so wide a range that often persons write to the Survey for information wholly unrelated to its official investigations—for instance, to inquire for persons who have disappeared and whose whereabouts are unknown except that they proposed going to Alaska—and strange to say, the desired information has sometimes been obtained from the memory or notebooks of one of the Survey staff.

The mere collection and assembling of information regarding Alaska is, however, of little general significance, unless the information is made known. The Geological Survey, to meet the duties of its trust as the consulting geologist to the people of the United States in geologic matters, must make its findings that are of significance to them readily available. This is done principally through its formal reports and general notices and through specific answers to thousands of widely scattered correspondents. Already more than 400 separate reports regarding different Alaskan districts or subjects investigated by the Survey have been printed and widely distributed. Almost all these reports contain not only textual descriptions of the subjects treated but also graphic representations in the form of maps. The more comprehensive reports also contain other illustrative material, which gives vividness and clarity to certain phases that can be best explained by that means.

From year to year the specific work undertaken by the Alaskan branch differs both as to its character and as to the areas in which it is done, so as to meet best the current needs of the mineral industry and to utilize most effec-

A GEOLOGICAL SURVEY'S GEOLOGIST MAKING OBSERVATIONS AS TO THE RICH GOLD-BEARING PLACER DEPOSITS IN ALASKA.

A GEOLOGICAL SURVEY OUTFIT OF MEN AND HORSES

CROSSING RUSSELL GLACIER, ONE OF THE STREAMS OF ICE IN THE EASTERN PART OF THE COPPER RIVER VALLEY, ALASKA.

tively the funds and personnel at its command. An idea of the general type of work done may be obtained from the following summary, which outlines the ten projects chargeable to funds directly appropriated to the Geological Survey that are in progress for the current year. Seven of these projects involve both field and office work and are as follows: Reconnaissance topographic mapping in

RIDING BEHIND THE DOGS

WHILE BUNDLED UP WARMLY AND ON A GOOD TRAIL WITH A LIGHT LOAD IS EXHILARATING FUN, BUT THERE IS SELDOM A CHANCE TO RIDE ON THE GEOLOGICAL SURVEY SLEDS WHICH MUST BREAK THEIR OWN TRAILS AND ARE USUALLY HEAVILY LOADED, SO THAT THE MEN WORK HARDER THAN THE DOGS TO MAKE THE NECESSARY MOVES.

the Wrangell district and adjacent parts of southeastern Alaska; mining studies in the Taku district, near Juneau, and at other points in southeastern Alaska; reconnaissance topographic surveys in the mountains at the head of the Copper River and in isolated unmapped tracts adjacent to the Richardson Highway between Valdez and Gulkana; reconnaissance geologic surveys in the Tonsina district, in the west-central part of the valley of the Copper River; reconnaissance topographic mapping of the northern part of Kodiak Island and adjacent islands in southwestern Alaska; a geologic reconnaissance of parts of the Alaska Peninsula and the Aleutian Islands, in connection with an expedition sent by the Navy Department into that region; and general studies of recent mining developments throughout Alaska. The three projects for the present year that involve principally office work, though they are based in large measure on results of field work, are the annual canvass of mineral production for the calendar year 1932; the completion of a comprehensive report on the geologic features and mineral resources of the whole region in central Alaska lying between the Yukon and Tanana Rivers, which will summarize and correlate the results of more than 30 years' field work; and the general work performed by the main office of the branch and the field offices at Juneau and Anchorage, Alaska.

In addition to the projects listed above the Alaskan branch conducts all the investigational work on mineral resources financed by the Alaska Railroad under its authorization "to ascertain the potential resources available that will affect railroad tonnage." This work for the current season involves planning and technical supervision of two projects directed toward determining by means of diamond drilling, the resources of two coal fields adjacent to the Alaska Railroad; a combined geologic and topographic party to survey and examine more than 1,000 square miles of hitherto unmapped country lying near and on the flanks of Mount McKinley, in the Chulitna Valley, in central-southern Alaska; and a resident geologist at Anchorage to act as technical adviser to the manager of the Alaska Railroad. The Alaskan branch is also intrusted with the conduct of all field work required in connection with the administration of the mineral leasing laws so far as they relate to Alaska and are performed by the Geological Survey, though this work is financed by an allotment of funds from a separate appropriation item.

Why is the work outlined above undertaken by the government? This is really a double question, for by implication it raises both the query whether the work itself is worth doing and, if that is answered in the affirmative, the query why it should be done by the government rather than by private individuals. It would be presumptuous for a person closely connected with the work to attempt to dispose of the first part of that question. Suffice it to say that there is a continuous demand for the Survey's past publications on the different mining districts and an insistent call for it to undertake the exploration of additional tracts that have not yet been reported on, and that throughout Alaska at least the Geological Survey has a most enviable record of accomplishment, at an extremely economical cost. I know of no group of government employees who are recognized by the public they aim to serve as having more indefatigable industry, greater pioneering ability, higher professional skill, or more thorough integrity than the group of past members of the Survey's Alaskan unit.

If, then, we may accept the fact that the work of the Alaskan branch has re-

MEMBERS OF A GEOLOGICAL SURVEY PARTY

LINING THEIR BOATS LOADED WITH THEIR SEASON'S EQUIPMENT AND SUPPLIES UP ONE OF THE SWIFT-FLOWING RIVERS OF NORTHERN ALASKA.

ceived the indorsement of the people in general and financial support through Congress in spite of various economy programs for nearly 35 years, as warrant for assuming that the project of itself has merit, we may attempt to answer the second part of the question—namely, Why is this the government's job? Much more than nine-tenths of Alaska still remains absolutely in the possession of the national government. Therefore the government's own interest as landlord would alone suffice to necessitate its undertaking the work. Knowledge of the physical features of its holdings and of their resources that may be of value is obviously indispensable for intelligent development, profitable utilization and effective administration. A private landowner would be regarded as extremely lacking in business sense if he failed to determine the bounds and resources of his estate and had not formulated a wise plan for its development. If the private owner hoped to dispose profitably of parts of his property to others he would necessarily take those steps if he expected to be successful. The government is conducting a vast business in disposing of its lands, and its responsibility goes beyond that of any private owner, for it endeavors to make sure that the resources of these lands are wisely exploited.

Although in the foregoing statements emphasis has been placed on the government's own need for information of the type furnished by the Alaskan work of the Geological Survey, that need is of course not something wholly apart from the needs of its citizens. On the contrary, the "Government" and the citizens are one, and their interests and needs coincide rather than run at cross purposes. For that reason the same type of information regarding Alaska's mineral resources that the administrators of the government's activities need is also useful to the individual men and women who see Alaska as a land of opportunity for their endeavors. Without their private enterprise to develop these re-

sources the many facilities which the government provides and, in fact, the whole of the government's activities in the Territory would became inconsequential and of little avail. Of course, some of this information might be collected by equally proficient geologists and engineers in private employ, but that would lead to considerable waste effort and duplication because, as a rule, the results of such examinations are not made public, and the same work would be done over and over again by each succeeding examiner. But some of the work could not be done by persons in private employ because the government geologists have access to many sources of information that usually are not available to private engineers. For instance, one of the projects carried on under this item each year is the comprehensive canvass of the output of the different mineral commodities. The production of gold from an individual mine is of itself a private matter that is regarded as more or less a secret, and yet knowledge of the total amount of gold produced from all the mines in different districts or of different types is significant to world policies as well as those of more local circles. The collection of such information necessarily must be carried on by some such organization as the Geological Survey, which can be relied on to respect the confidential character of the information supplied and has so comprehensive a knowledge of the mining industry throughout the Territory that its findings are complete, continuous, and reliable. However, although many types of mineral investigations can be made best by geologists of an official organization like the Geological Survey, there are unquestionably others that such an organization can not as well undertake. In full realization of this distinction the Geological Survey refrains from entering any of the enterprises that can be better done by others. So scrupulously has this policy been adhered to that such adverse comments as have been heard indicate that some companies and individuals feel that the Survey does not go as far in certain lines as they wish, rather than that it oversteps appropriate bounds.

TOPOGRAPHER WITH ASSISTANTS ON STATION

USING PLANE TABLE AND ITS ACCESSORIES TO MAP THE MOUNTAINS AND VALLEYS OF ALASKA.

MEN AND DOGS WITH THEIR PACKS

LOADED FOR CROSS-COUNTRY TRAVEL IN THE CONDUCT OF THE EXPLORATORY SURVEYS MADE IN MOUNTAINS OF NORTHERN ALASKA BY THE GEOLOGICAL SURVEY.

To write of the Alaskan branch only in terms of the past might leave the impression that its days of strenuous labor are over and that it has fulfilled its mission. Such an impression, I believe, is not warranted, for as I see the future needs there is and will be an increasingly greater demand for the kinds of service it is qualified to give. Less than half of the vast area of Alaska has been mapped and investigated on even reconnaissance standards, so that there is more than 300,000 square miles, or an area about 35 times the size of Massachusetts, that has not been surveyed, and probably in at least two thirds of that area there are tracts which may contain mineral deposits that are worthy of development. In addition, there is a continuing need for more detailed and precise studies in many of the camps that were only cursorily examined in the course of the earlier exploratory or reconnaissance surveys. Probably in most of the long established camps the more obvious deposits have already been found, so that to bring to light the more obscure and yet perhaps equally worth-while deposits that may be developed in the future will require far more critical and intensive work. The type of information that was adequate for the pioneer who mined in a small way is no longer exact enough for the larger operators whose preliminary outlays run into millions of dollars. Nor is the technique of searching for ore deposits at a standstill, for advances are being constantly made, and these more refined methods and equipment are furnishing tools by which problems that were beyond the attack of earlier geologists can now be undertaken with considerable assurance of obtaining results of significance. The Territory itself is constantly being more and more opened up, so that districts which were once remote are becoming accessible, costs in them are being lowered, and therefore some of their deposits that formerly were not worth considering are fast nearing the limits of workability. All these things clearly indicate that if it proves fit to grasp the larger opportunities offered, the Alaskan branch of the Geological Survey will continue for a long time to find problems relating to the mineral resources of Alaska which will require for their solution its best efforts and its utmost skill.

# ON THE RESEARCH WORK OF THE U. S. WEATHER BUREAU

By Dr. W. J. HUMPHREYS

WEATHER BUREAU, UNITED STATES DEPARTMENT OF AGRICULTURE

By act of Congress it is the duty of the U. S. Weather Bureau to keep continuous records of the state and condition of the sky and the air at many places, to issue forecasts, based thereon, of the temperature, wind, rain and other weather elements of the morrow and the day after, and also from these records to discover the climatology of each and every portion of the country.

To perform this public service at all satisfactorily it was necessary first to provide for obtaining reliable records of the temperature of the air, degree of humidity, amount and kind of precipitation, wind direction and velocity, cloudiness and sunshine, and also very accurate measurements of that special condition of the atmosphere, namely, its pressure, which though inconspicuous to our senses nevertheless is so related to weather changes as to be exceedingly valuable to any one who, from to-day's weather, forecasts that of tomorrow.

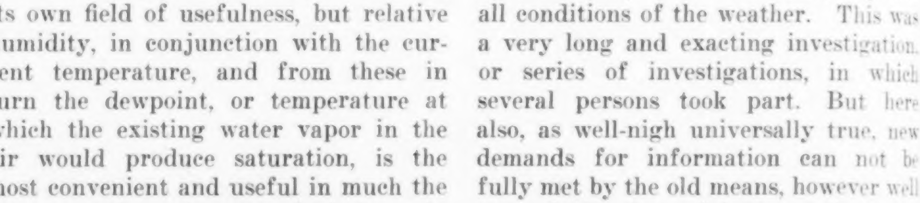
Thus was necessitated a long series of investigations that had as their object the securing of records accurate enough for the uses to be made of them, with apparatus inexpensive, sturdy, durable and convenient. Of course those without experience in such matters might think that this would be the easiest sort of thing to do. For instance, one who has not tried it naturally is cocksure that an accurate measurement of the amount of precipitation is the simplest thing in the world to effect, and indeed rough measurements of it are easy to make, and have been made for many centuries. Clearly, too, the measurement of the water caught for that purpose offers no difficulty, but investigation soon revealed the disturbing fact that the amount of water captured by any and every rain gage varied with the nature and proximity of neighboring objects, height of the catching vessel above ground, strength of the wind, and other factors. Hence a number of investigations were required to determine the kind of apparatus to use to catch the rain, where to expose it, and how to construct it so that it automatically would make a reliable and convenient record of the time of occurrence, rate of fall and total amount of each and every rain that came.

But a device that is satisfactory for catching rain may be, and generally is, poorly adapted to the catch and measurement of snowfall. Therefore another series of investigations had to be undertaken to make the measurement of snow practicable and reasonably accurate. Furthermore, the amount of snow accumulation, especially in mountainous regions, is important, since in many cases it determines the volume of stream flow and the quantity of water available for irrigation and other uses in the valleys and plains below during the coming summer and fall, and because of its importance this accumulation must be measured, not guessed at. This problem in precipitation, too, has been solved with fair success.

Humidity is another weather factor, closely related to precipitation, that must be measured because it affects our comfort and our health, because it is important in many industries, and because a knowledge of its values at a given time over an extensive area

likewise is very helpful to the forecaster of the coming weather. But how shall this humidity be expressed? We have our choice between absolute humidity, that is, the weight of water vapor per unit volume, such as grains per cubic foot, or grams per cubic meter; relative humidity, or ratio of the water vapor present per unit volume to that which, at the same temperature, would produce saturation; specific humidity, or ratio of the weight of water vapor per given volume of air to the total weight of the same humid air; and vapor deficit, which likewise may be expressed in two or three different ways. We have our choice, as just stated, between these several ways of measuring and expressing humidity, but what shall the choice be? That depends on the use to be made of the data. Each has its own field of usefulness, but relative humidity, in conjunction with the current temperature, and from these in turn the dewpoint, or temperature at which the existing water vapor in the air would produce saturation, is the most convenient and useful in much the larger portion of meteorological work.

Surely, though, the measuring of humidity, once we have determined what kind we want, is easy—so elementary that any high-school boy or girl taking the science course can tell you all about it. You merely have to pass a known volume of the humid air slowly over a highly drying agent which you weigh before and after the flow. This gives both the volume of the air (if the temperature and pressure have been kept constant) and the weight of the water that was in it, and there you are, at least for absolute humidity. Nice, to be sure, but that process takes more time than can be allowed an observation in the practical, current work of a weather-forecasting service. There was nothing for it then, but to go to work on the development of a speedy and reasonably accurate method of determining the current humidity of the air under any and all conditions of the weather. This was a very long and exacting investigation, or series of investigations, in which several persons took part. But here also, as well-nigh universally true, new demands for information can not be fully met by the old means, however well they fulfil the original requirements. The new demands in this case are for



CENTRAL OFFICE OF U. S. WEATHER BUREAU AT WASHINGTON, D. C.

AIRPLANE OBSERVATIONS
ARE BEING MADE AT SOME WEATHER BUREAU AIRPORT STATIONS TO TAKE THE PLACE OF KITE OBSERVATIONS. NEWARK, N. J., MAKES SUCH OBSERVATIONS BUT NOT DAILY. THIS PICTURE SHOWS THE LASHING OF THE AEROGRAPH ON WING OF PLANE FOR WEATHER HOP.

continuous, automatic and accurate records of the humidity. So far this exacting problem has been only imperfectly solved. It deserves and doubtless will receive much further investigation.

Closely associated with humidity is the phenomenon of evaporation, on which literally hundreds of papers have been written, ranging from scores that are utterly worthless to a few that are excellent and really get somewhere. To this difficult and complicated problem the U. S. Weather Bureau has contributed its full share, both in design of equipment and in actual measurements. Nevertheless, the equations thus far developed to express the rate of evaporation are either empirical or else based on assumed conditions that do not very closely obtain in nature. However, at a number of places systematic measurements of evaporation are made with standard equipment that at least will furnish valuable climatological information.

Wind vanes, used from the days of the Romans, were readily adapted to indicating and recording the general direction of the wind, though even here a marked improvement was but recently made by giving the tail of the vane a streamline shape—an improvement suggested by certain investigations on the relation of shape to wind resistance. The measurement of wind velocity, however, was a much more difficult problem, complicated also by the fact that a portion, at least, of the measuring device has to be exposed to all sorts of weather. Through a series of investigations a practical solution of this problem was found that was adequate to the then needs, but the needs did not remain constant. Aviation has imposed upon us the necessity of solving the problem of air turbulence, and that means, as a preliminary to that solution, innumerable accurate records of wind direction, velocity and acceleration under various conditions of weather and terrain. Promising starts on this investigation have been made both in this country and abroad, but years of tedious work are still in prospect for those who would solve this important problem in all its complexity.

All these and many other investigations were essential to the adequate measuring and recording of the state and condition of the surface air. But precipitation and most of the other weather phenomena come from the free air, or are affected by it, and so the necessity was upon us to devise some means of sounding the air miles deep for its temperature, humidity, direction and velocity of movement, and any other state or condition that indicates the nature of the coming weather, or assures the aviator of what sort of atmospheric disturbance, if any, and where, he reasonably may expect aloft.

The effort to obtain this desired knowledge of the free air led at first to elaborate investigations and developments of the meteorological kite and

its equipment. Later on, the airplane, which wanted the air free from kite wires anyway, took over the equipment designed for the kite and now is regularly furnishing all the information the kite could give and more besides, and doing it more regularly, since it can go up in any wind a kite could stem, and also in wind too light to get a kite off the ground.

So much, then, in the way of mere hints, as it were, of the numerous investigations, recorded on many thousands of printed pages, incident to the design, construction and operation of the various kinds of apparatus used in obtaining reliable, serviceable and continuous records of the state of the weather.

In addition to the current use by the weather forecaster of the data obtained by means of kites, airplanes and pilot balloons—little toy-like balloons that, when properly inflated and followed by a theodolite, give the direction and velocity of the wind at various heights—they (these same data) also were employed in detailed studies of the change with height of temperature, humidity, wind direction and wind velocity as determined by time of day, season of the year, location, distribution of atmospheric pressure and state of the weather. Much knowledge of the air and its ways already has come from these studies, and it is reasonably certain that with increase of data this knowledge will become more comprehensive, more exact and more useful.

In the use of meteorological data for weather forecasting, one of the chief functions of the Weather Bureau, it is necessary of course to free them, as far as possible, from local influences so that as corrected they may represent the true expression of the general or widespread state of the atmosphere. For instance, a hill or other large object may be so situated as, in some cases, to cause air eddies at the location of the wind vane and thereby to cause it to register wind directions quite different from those that belong to the real distribution of the weather roundabout. Such effects must be investigated and the proper corrections determined. Again the minimum temperature at and near the surface of the ground on still clear mornings may, and often does, vary by 5° to 10° F., and occasionally by even 15° to 20° in a radius of 5 to 10 miles, and that too without a difference in elevation of more than 100 to 200 feet, or perhaps less. Such large local variations, if to be allowed for at all, as in some cases they should be, require a detailed survey of the region in question. This is particularly important wherever protection from frost or freeze is necessary.

In addition to these local weather irregularities, there is one general phenomenon, namely, atmospheric pressure,

REAR END OF THE NEW FIRE-WEATHER TRUCK

SHOWING RADIO RECEIVING EQUIPMENT. THE TRUCK IS ALSO EQUIPPED WITH METEOROLOGICAL INSTRUMENTS WHICH ARE OPERATED BY A TRAINED OBSERVER. THIS TRUCK IS USED BY THE WEATHER BUREAU AND FOREST SERVICE OF THE U. S. DEPARTMENT OF AGRICULTURE.

—F. Ellerman, photo.

NIMBUS CLOUD ABOVE, FOG BELOW

that so differs from station to station that to render its values comparable among themselves, and of weather significance, all must be reduced to what under the existing conditions they would be if the various stations had the same level. In practise, and for reasons too tedious to explain here, it has been found that the best level for this purpose is sea-level. This, however, is a case where a correct solution of the problem, and which we know to be correct, can not be obtained. Nevertheless it is so important that a vast amount of investigation was given to it, until at last a tentative practical result was found which usually applies fairly well to our own stations. We know also the conditions under which this solution is likely to be highly erroneous, in which cases the forecaster wisely is on his guard, and, ignoring the local readings of the barometer, bases his judgment of the coming weather on other meteorological elements. A natural suggestion in this connection, and one to which much attention has been given, is that the pressure maps be constructed for some one definite height, or for two or more definite heights, above sea-level, and actually in the air. This looks like a good and practical plan, but no easy method has been devised whereby the atmospheric pressure can be obtained at exactly a thousand feet, say, up in the air. It can be computed, but no more accurately than the reduction to an equal distance below the surface.

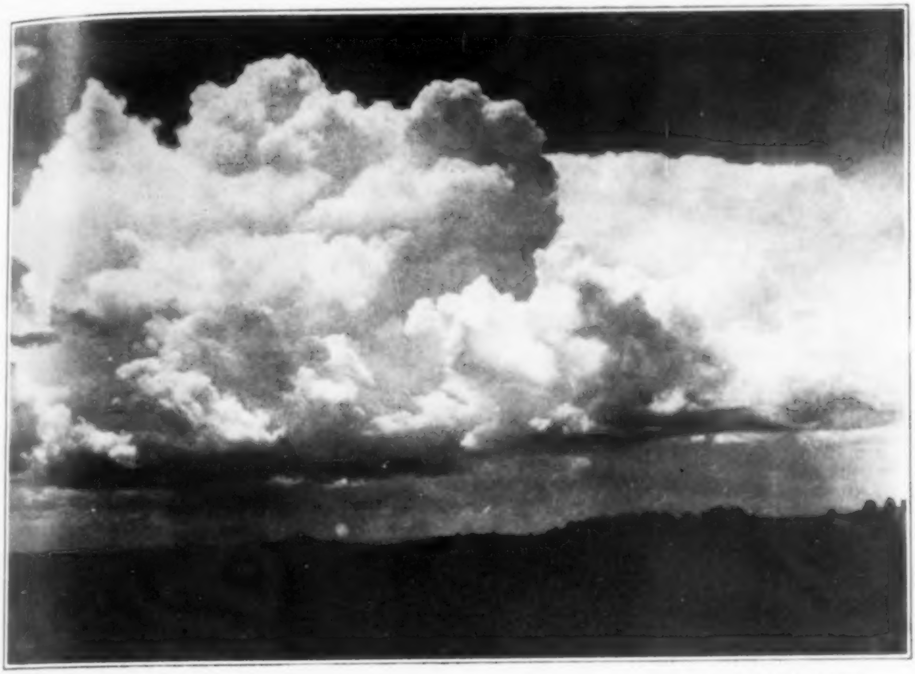
An interesting study, more or less analogous to that of the reduction of barometer readings to a common level, is that of the isentropic surface, the surface over which air moves with least resistance. A knowledge of the distribution of pressure over this surface might be very helpful to the forecaster, but at present that information is not available, because, for other reasons, the surface in question never stays fixed in shape so that simultaneous reduction of the pres-

sures at various places to the same isentropic surface is impossible. Clearly, then, the problem of the reduction of the barometer in such manner as to adapt it to a map of the simultaneous weather over a large area of mountains and plains has not yet been satisfactorily solved, nor is the way to such a solution at all evident. Improvements over our present practise in dealing with this weather element no doubt will be made, for as long as it appears on the weather map (and it is too useful to drop) those who realize the seriousness of the errors in its present representation must feel a challenge to find a more reliable and helpful way of charting it.

Another subject to which much attention has been given, but of which our knowledge still is far from satisfactory, is that of fogs and clouds. We can not even classify them in a really satisfactory manner, that is, according to the methods by which they were formed, a method that would be especially helpful in making clearer their meteorological significance. At present we classify clouds according to their appearance, of which we often are in doubt, and height, which commonly is scarcely more than guessed at. Some clouds that look alike, and therefore have the same name, are formed in quite different ways and imply different sorts of coming weather. Others, on the contrary, differ widely in appearance, but little in origin and significance. In short, clouds and fogs, despite the numerous investigations that have been made of them, have given us but a fraction of the abundant meteorological information they evidently contain.

Perhaps the most fundamental of all meteorological problems is that of the reception and disposition of solar radiation. Indeed, this has led to a multitude of investigations in which the U. S. Weather Bureau has taken a creditable part, and in which it expects to continue to assist so far as practicable. This general problem involves the frequent determination of the amount of solar radiation reaching the outer atmosphere, its selective absorption by the constituents of the atmosphere, especially oxygen (both diatomic and triatomic, or ozone) carbon dioxide and water vapor, hence also the varying amounts and distribution of these substances. It involves likewise the quantity, kind and distribution of dust throughout the atmosphere, and the kind and extent of clouds. All this and more besides concerns the incoming radiation, and the supplementary questions of how the earth disposes of this radiation are equally numerous and important, but as yet far less well understood. A large part of the incoming sunshine is lost at once by reflection and by scattering, while that which is consumed by direct absorption or otherwise must go off to space by long wave-length radiation. But this is terribly complicated by the substances of the atmosphere, particularly water vapor, carbon dioxide and ozone, and the things in the air, such as dust and cloud, and where they are, high or low. Involved here also are numerous problems of health, plant growth, air pollution, country versus city, and many others, all crying for investigation and solution.

As already stated, a major duty of the U. S. Weather Bureau is that of forecasting the coming weather for a day or two for all parts of this country. Hence several investigations have been made of the movements of cyclones and anticyclones over the United States and adjacent regions. In the main, and of necessity, these studies were for facts rather than ultimate causes, which perhaps may be discovered later. They were primarily for the important purpose of enabling the forecaster to predict the coming weather more accurately and for a longer time ahead than before had been possible. As stated, this was their prime purpose, and this, too, was their for-



—A. J. Weed, photo.

CUMULO-NIMBUS CLOUD

tunate result. Furthermore, this valuable line of investigation is still in progress with elaboration here and refinement there, with always a gain in our knowledge of the weather and its endless changes.

In addition to the general cyclone of extratropical origin and progress that so frequently passes over one or another portion of the United States, the similar, and yet widely different, storm from the tropics, the violent and destructive hurricane, must be carefully studied to the end that its coming may be predicted as accurately as possible both as to time and place. Much study has already been given to this storm, especially in the form of collecting and assembling the facts as to times of occurrence, tracks followed, strength of winds, amount of precipitation and other matters that can in any way aid the forecaster in predicting the intensity, course and general behavior of any hurricane that may be in existence at the time. Here, too, further investigations are needed, in particular such as will aid to an understanding of the genesis of the tropical cyclone, its detailed structure and the manner of its maintenance.

Other meteorological phenomena that have been extensively investigated by the U. S. Weather Bureau are the tornado, the most violent of all atmospheric disturbances, and the thunderstorm. Each has been studied as to place of occurrence, relation of frequency to time of year and hour of day, and also in respect to their origin, maintenance and mechanism.

Not all weather forecasting is that of predicting rain or foretelling a day of calm and sunshine. A very different and difficult kind is the important one of warning of forest-fire hazard. This service is based on investigations of the dependence of the inflammability of duff and other forest material to the weather

not only of the present day but also of the several days previous. Especially are temperature, humidity and wind of importance in this connection. It also is quite helpful to know whether or not thunderstorms will occur, and whether they will be accompanied by much rain or only a little to none. Investigations of this problem have only fairly begun, but already they have abundantly proved their worth.

Another specialized investigation is that of the weather conditions likely to lead to the formation of ice on airplanes. This necessitated first of all a collection of numerous records of actual cases of the formation of ice on the planes, and then a careful analysis of these records to learn from them the exact conditions under which the ice is deposited, and the type of storm in which this phenomenon is most likely to occur. This investigation too is incomplete, but nevertheless has gone far enough for the results obtained to be of great value to the aviator who has the proper regard for the safety of plane and passenger.

Several other specialized forecasts of the weather have been requested and supplied, each requiring investigations peculiar unto itself. One of these may be cited here, owing to its great value and extensive practise, namely, fruit-frost warnings. This kind of specialized forecasting has been most extensively investigated, and is most generally practiced, in connection with the citrus industry, which otherwise could not exist in this country to anything like the flourishing extent it does.

Cranberries also are systematically protected from frost injuries, but as a rule by entirely different methods from those used in the case of orchard fruits, and therefore, as well as because of the usual great difference between the temperature curves over a cranberry bog and in an orchard, predictions for this purpose had to be based on independent investigations.

Forecasting for frost protection is profitably extended to truck farming also, especially in sections where winter trucking is practical, such as the more southern portions of the country.

In addition to all the above there is quite a different sort of weather forecasting that almost every one seems to want, and which many people make for themselves, with never a failure—if you can believe what they say about it—but for all that a kind which very few well-informed meteorologists ever make, at least for publication. This is what is known as "long-range" or seasonal forecasting. It would be a matter of great importance if we could predict the weather with approximate accuracy months in advance, and innumerable attempts have been made to do this. Most of them are wholly irrational, being based on such things as onion skins, corn husks, moss on trees, squirrel stores, fox furs, etc., etc., through a list that ends only with one's patience in looking it up. But, on the other hand, some of the guides to long-range forecasting are altogether rational and worthy of serious consideration, however meager the results thus far obtained. Those rational guides are such things as depth and distribution of the snow covering; volume and temperature of ocean currents; and periodic or cyclic recurrence of much the same sort of weather. A vast amount of attention has been given to the study of weather cycles by meteorologists of different countries, and also by some capable students who are essentially astronomers or mathematicians. Thus far, however, the results of these studies have been disconcertingly poor. Cycles galore—many more than 100—have been found ranging from 744 years to 24 hours, but except for the diurnal cycle and the annual cycle all appear to be either too small in amplitude, or too uncertain, as soon as applied to the *future* to be of any forecasting value whatever.

But the end sought, successful sea-

SNOW SURVEYOR
OF THE U. S. WEATHER BUREAU, WITH HIS SAMPLING TUBE AND SCALES, OUT ON A SURVEYING TRIP. (C. S. 736.)

sonal forecasting, is most important and therefore every rational lead in that direction should, and will, be followed to its conclusion. The situation in this connection is at present discouraging, but in science one never gives over trying until the quest has been definitely proved to be hopeless.

In the meanwhile it might be justifiable in some cases to make a seasonal forecast, properly explained and qualified, based on "trends," such as a number of consecutive winters colder than the normal, or warmer, as the case may be. After several such winters, say, had occurred in succession one might assume that the next would be of the same type, but such an assumption is risky, for sooner or later the series is sure to fail. If we understood the causes of trends we would be well on the way towards using them as safe guides in seasonal forecasting, but until we do acquire that understanding the forecaster who depends on understood causes and effects is certain to regard them with suspicion.

However, whether or not we shall ever be able reliably to predict the weather a season, or a year, ahead, at least we can assemble in convenient form the records of the past weather for as long as the records have been kept, and in many respects that is just as valuable as long-range predictions would be, because by and large the run of the weather at a particular place is much the same through any one year as through any other. This likeness does not, as every one knows, extend to details. In fact, these details may so vary as to make one year fruitful and another barren. Nevertheless, they do not so change as to convert previous deserts into enduring fertile plains, nor pleasant lands into frigid wastes—at least such changes are not wrought in a generation, nor have been, so far as we know, in the lifetime of any nation. Therefore the history of the past weather of any place, its climate, is a reliable general index to its future weather. This is why climatology has been, and is now being, so assiduously studied, and why the Weather Bureau has devoted to it so many investigations, both general and in detail. The subject is well-nigh inexhaustible. Indeed, it is no exaggeration to say that a large volume might profitably be devoted to the climatology of each and every county in all the states of the Union, and in many cases even such a single volume would have to be rather general and superficial. The climatology of one city alone in this country has been condensed (that is the proper word) into two large volumes. But what a labor! To record in adequate detail the meteorological data necessary to such a climatology of this country, and to assemble them in proper form and print the resulting volumes would keep all our idle population fully occupied for a cen-

tury; and then revisions and supplements would be necessary to keep the information up to date.

Somewhat akin to climatology are the various subjects that are grouped together under the general name of agricultural meteorology. This particular branch of meteorology has to do especially with the relation of crop yield to the weather conditions over particular periods, and is different for different regions and different crops. It also is further complicated by the fact that not one weather element, but the combination of several, enters into the final result, and additionally entangled with the effects of differences in quality of soil and lay of the land by virtue of which the weather that is good for a given crop on the one may be bad for the same sort of crop on the other. But despite the complexity of this subject investigations already have disentangled from it several helpful generalizations, and more are in sight for whoever has the courage to till this bramble field, and is well supplied with the necessary equipment therefor.

The above references to climatology and its kindred subject, agricultural meteorology, relate to surface conditions, the conditions that formerly were about all that really concerned us. Recently, however, we have taken to the free air as a medium of conveyance, and therefore have become concerned in free-air climatology, and more especially in that portion of it which has to do with the directions and speeds of the wind at various flying levels, or, specifically, from the surface of the earth to (at present) the height of six miles, at least, above sea-level.

To ascertain these facts for the whole of the United States would be an investigation of gigantic proportions, but it long has been in progress, and the results already attained are of great value and in constant use. Of course, too, any one scientifically interested in climate and the primeval element of which it is made, that is, weather, is curious to know what brought about the great climatic changes of the geologic past. This problem is not yet certainly solved, but its study has greatly increased the extent and accuracy of our knowledge of the several things that control climate and how they in some cases supplement, and in others counteract, each other. The investigation, in this connection, of how volcanic dust in the upper atmosphere can produce its known effects on sunshine and surface temperature was especially interesting and suggestive.

Another investigation of fascinating interest was that of why the temperature of the atmosphere must decrease at the rate at which it actually does up to a certain height, generally 6 to 7 miles above sea-level, in middle latitudes, and then become constant, or nearly so, for an unknown distance beyond.

Other investigations of atmospheric and weather phenomena and their causes have been undertaken by the score and all the findings fully published.

Also, as a matter of some interest, all the hundreds of weather proverbs that have accumulated through the ages have been examined, and the rational, based on actual physical conditions, separated from the irrational and explained.

Likewise, all known schemes for inducing rainfall, or preventing it, have been critically examined, and the cause or causes of the failure of each fully explained.

But what, then, were the other weather services of the world doing the while these investigations were in progress here? Much the same things, especially in relation to the conditions peculiar to their respective countries.

And what justification is there for such investigations on the part of a public institution? The improvement in that institution's service to the public which the knowledge thus acquired guarantees and makes permanent.

# SCIENCE AIDS IN MOLDING BETTER LIVE STOCK

By Dr. JOHN R. MOHLER

CHIEF, BUREAU OF ANIMAL INDUSTRY, UNITED STATES DEPARTMENT OF AGRICULTURE

The process of selection, which has played so large a part in molding the form and functions of animals into breeds of live stock, as we know them to-day, is an outgrowth of man's early attempts to domesticate animals. Those judged by the owner to be the best for his purpose were commonly kept the longest and produced the most offspring. True, many erroneous beliefs concerning heredity have existed and retarded live-stock improvement immeasurably. Yet, even the earliest live-stock owners practised selection and, judging from ancient carvings, produced some highly creditable types of domestic animals.

The passing of centuries added much practical experience but comparatively little exact scientific knowledge until in 1865 the Austrian monk, Gregor Mendel, made certain observations in plant breeding and selection. Papers reporting his observations attracted very little attention at the time, and he died in 1884 without realizing the importance of the work which he had done. Later other investigators, working independently, rediscovered the principles of breeding—now commonly known as Mendel's law—that he had formulated. This knowledge has wide application in live-stock breeding.

Through Mendel's discovery and subsequent research on the mechanism of heredity, breeders have been able to develop strains highly productive in various respects, such as milk yield in the dairy cow and egg production in poultry. Certain characteristics are known to be dominant and in practically all cases will appear in the progeny. The white face of Hereford cattle, and the absence of horns in the Galloway, Aberdeen-Angus and Red Polled breeds are known as dominant characteristics. When an animal having one or more of these dominant traits is mated with another animal lacking these, the former's characteristics will be reproduced in the new generation. In time the desired characteristics can be established or "fixed" by mating animals both of which have the same desirable characteristics.

### Breeds and Types Are Results of Selective Process

Thus live-stock breeding has established numerous breeds and types of domestic animals that excel in various specialized purposes. Other breeds ably serve a dual purpose, combining the production of meat with another commodity, such as milk, wool or eggs, in an efficient manner.

When one considers that practically all live-stock breeding in the United States is under human control and that considerably more than 100,000,000 animals are born annually, the significance of scientific studies and their practical application to this field are obvious. They involve many practical questions, some of which have been satisfactorily answered, while others are still under investigation. Particularly in those problems which relate in a broad manner to the welfare of the live-stock industry and the interests of the public,

the Bureau of Animal Industry has participated actively.

Recognizing the live-stock owners' need for basic facts about heredity and methods of live-stock improvement, the bureau prepared, about a decade ago, two publications. One, designated as "Essentials of Animal Breeding," sets forth in popular form information which previously had been relatively inaccessible. A second and more scientific discussion of the subject was prepared for the more advanced breeders and others who wish to go deeper into the study. These publications have been in extensive demand.

Simultaneously with the preparation of the publications mentioned, the Bureau of Animal Industry urged the use of pure-bred sires for grading up inferior live stock. This policy has been continuously stressed for more than a decade. It has been adopted by more than 17,000 live-stock owners, many of whom have reported extensive benefits resulting from its use. Typical benefits include the production of higher quality and more uniform offspring, earlier maturity, greater productivity, readier salability and other assets to the stockman's business. For the information of those unfamiliar with stock-breeding operations, it may be explained that the reason for emphasis on the sire has a mathematical basis. In stock breeding the sire is a parent of vastly more progeny, on the average, than is the female animal. This explains the significance of the expression, "The sire is half the herd."

## Interest in Live-Stock Improvement Is World-Wide

To provide full opportunity for the public discussion of principles of stock breeding and the policy of encouraging use of pure-bred sires, the bureau has issued a considerable quantity of data in the nature of evidence. Likewise it conducted, with the assistance of other

A SLAUGHTER SCENE IN ANCIENT EGYPT,
ILLUSTRATING CREDITABLE BEEF TYPE OF CATTLE DEVELOPED BY PRIMITIVE MAN.

EXTREMES IN EQUINE STOCK.
THE SHETLAND PONY COLT AND THE PERCHERON STALLION PROVIDE A STRIKING COMPARISON.

government agencies, a world survey showing what other important live-stock countries have been doing along similar lines. The results of this survey showed that live-stock improvement is progressing the world over and is stimulated to some extent by competition in the sale of surplus breeding animals, meat and other animal products.

The free public discussion of live-stock improvement was further encouraged by the sponsoring of public mock trials at which an inferior bull, for instance, was the prisoner in "court." These trials, held in various parts of the country, have not only influenced future live-stock breeding, but have resulted in the actual condemnation and slaughter of many inferior sires.

Besides these rather general activities the Bureau of Animal Industry has conducted numerous experiments, the results of which have materially augmented knowledge concerning animal breeding. More specifically, the work has centered largely on means of making production more economical and of improving the quality of meat and other products. In this work the bureau has cooperated extensively with other branches of the government, state agricultural experiment stations and representatives of the live-stock and meat industry. These relationships have

given breadth to the study and have brought to the attention of scientific investigators various commercial angles of the problems. For instance, in pork production certain feeds, such as peanuts and soybeans, though nutritious and otherwise desirable, have a tendency to cause a soft or oily condition of pork and lard that is objectionable to many buyers. The problem in this case was to develop rations and methods of management that would yield pork of satisfactory firmness and yet include some of the so-called softening feeds.

Another problem in recent years has been the great demand for small cuts of meat to meet the requirements of small families and small kitchens. The preference for a steak that can be cooked on a small electric grill, in a measure influences the breeding of live stock on western ranches. Similarly, the consumer's demand for small legs of lamb and choice chops explains in part why about 90 per cent. of ovine stock marketed are lambs. Obviously many economic considerations, such as kind and quantity of available feed, cost of labor, differentials in market price for different grades of live stock, and other factors enter into the picture.

### Molding Animals Affects Internal Structure

Yet the process of molding more than 100,000,000 animals a year into the form for which the public has expressed its preference is in continual operation. Breeding and feeding are the predominant means of perfecting the desired animal types. This process of molding living animals to desired forms applies not only to the visible parts of the body but also to the internal structure, nota-

GROWING INTO THE BEEF BUSINESS.

AS A RESULT OF RESEARCH AND EXTENSION WORK, MANY FARM BOYS OF TO-DAY HAVE BECOME EXPERT IN PRODUCING EXCELLENT SPECIMENS OF LIVE STOCK.

A SCRUB-BULL TRIAL,

ILLUSTRATING A COMMUNITY'S EFFORT TO REPLACE INFERIOR BREEDING STOCK WITH MORE PROFITABLE TYPES.

bly the relation between the weight of dressed carcass and the weight of the live animal. This relationship, known to the trade as dressing percentage, varies widely, ranging from less than 50 per cent. to more than 75 per cent., according to the kind, breeding and market grade of animal.

Notwithstanding the essential functions which the vital organs perform in the growth and fattening of live stock, breeders have been highly successful in producing animals which yield a high percentage of the most valuable cuts of meat and a comparatively low percentage of organs and other so-called offal. In some instances hogs have dressed higher than 85 per cent.

The scientific study of these questions in recent years has involved refinements of methods, the application of numerous sciences, specially designed equipment, mathematical formulae and many thousands of experiment animals. Results are available in numerous publications, and the more practical phases likewise have been presented to interested persons by agricultural extension workers, the press, radio announcements, exhibits and other means.

### Typical Results of Current Research

The limits of this short discussion preclude the adequate presentation of recent scientific findings, but the following are typical examples:

A study to determine production efficiency in cattle and swine, based on breeding and feeding performance, carcass yield and quality of meat, resulted in the development of a mathematical system for measuring such efficiency and making comparisons.

The largest factor influencing a variation in firmness of lamb fat, with ordinary feeding methods, has been found to be the quantity of fat in the tissues rather than any variation in the character of fat itself.

Studies on firmness of fat in swine that were fed rations containing different percentages of cottonseed oil showed that the firmest fat was produced when cottonseed oil constituted 4 per cent. of

the ration. Larger percentages caused increased softness of fat.

Numerous feeding tests showed the comparative value of various rations, including those containing new feeds.

A simple method of determining, from a small sample, the clean-wool yield and density of fleece promises to aid sheepmen in the selection of breeding stock and the improvement of their flocks.

Observations on the influence of a sow's age on efficiency in pig and pork production showed that sows between two and three years old are most desirable for breeding purposes.

Experiments with poultry have resulted in the production of a flock in which yields exceeding 250 eggs per bird annually are common, some hens laying more than 300 eggs. This rate of production, which is more than three times that of average hens in the United States, shows the possibilities of selection and the application of improved methods in poultry raising.

For much the same purpose that various industries hold annual exhibitions to acquaint the public with new styles and improvements, the live-stock industry also holds numerous shows and expositions. Here the public may see the choicest specimens of the breeders' skill —the latest models, if you prefer—of potential steaks, chops, ham, bacon, wool, horseflesh, and scores of other animal products that contribute to our well-being.

# OTHERS[1]

By Dr. ROSS AIKEN GORTNER

PROFESSOR OF AGRICULTURAL BIOCHEMISTRY, THE UNIVERSITY OF MINNESOTA

I FIND myself to-night in a unique position, a single asteroid selected to represent that heterogeneous group of "others" who roam more or less at random through scientific space and whose irregular orbits weave in and out among the major planetary lights of the zoologists and the botanists. In the early days of our society this asteroidal group appeared to be a major planet; or at least a part of the great central nucleus from which all specialized sciences are derived. As time went on disintegration of the central nucleus occurred. The great planets of zoology and botany were thrown off from the central orb, and their ponderous mass, moving in wide sweeping orbits, attracted much of the atmosphere which had originally surrounded the nucleus. And then—following the rumblings which accompanied the birth of the major planets, there was an explosion of the residue of the nucleus, and a swarm of "other" asteroids burst forth to fill scientific space with minor planets, sweeping in irregular paths ,which in many instances cross and recross those of the major planets. It appeared as though the central orb had disappeared and that all that was left was a galaxy of stars, each moving in its own orbit "free from foreign entanglements." Emancipation had taken place! But the law of gravitation had not been overthrown! Sooner or later it was discovered that the major planets and the asteroids were still revolving around a common center, that each was mutually attracted to the other, that there was not a vacuum where the central orb had been, but that here the lines of force came together and that here it was possible to integrate all the diverse interests of all the galaxy of stars in a single nucleus—Nature! This, then, is the justification for the existence of the American Society of Naturalists.

With the complacency of age, and secure in their massive dignity of might, the two major planets strove for supremacy in the galaxy, forgetting for a time that they had a common origin and that in common with the "others." But their complacency did not long exist. The intertwining orbits of the major planets and of the asteroids occasionally provoked collisions. Sometimes an asteroid was captured and continued to revolve as a satellite around a major planet, but, more often than not, the collision had a disastrous effect upon the mass of the major planet, for by the force of the impact a portion of the major planet was detached and a new asteroid was born, sometimes to remain as a satellite, but sometimes to roam on its own irregular path through new and unoccupied regions of scientific space. Thus from year to year more and more asteroids were added to the galaxy, and the traffic problems of the major planets became more and more difficult.

In 1931, in a typical American fashion, a commission was appointed to study this traffic problem, and the report of that commission provides for a series of stop-go signals at points where the orbits intersect, with right of way given one year to the zoologists, one year to the botanists, and the third year to one of the asteroids—an "other"! Let us hope that this will provide a paradox—fewer collisions but more contacts!

The programs of the American Society of Naturalists are by tradition devoted

[1] Presidential address, delivered at the annual dinner of the American Society of Naturalists, Atlantic City, New Jersey, on December 30, 1932.

to some phase of the broad problems of evolution. As a representative of the "others" I do not intend to deviate from that tradition. But evolution is a broad word and may be interpreted from many standpoints. It may relate to mutations, or to progressive changes in genera or species, to changes in structural form, to changes in mental capacity, to changes in social organization, to changes in the career of an individual, or of the development from the individual to the family, to the clan, to the tribe, to the nation, to a specific civilization, yes, it may be the development of civilizations themselves; the relation of our civilization to the "other" civilizations which preceded us and to the "others" which are to follow. It is this phase of evolution which I wish to consider this evening, taking as my thesis that progress in material civilization is largely, if not wholly, determined by progress in the fields of applied science.

Yesterday, to-day and to-morrow! We are here! From whence came we? And whither are we going? And why?

It has been stated[2] that the earliest date in human history which can be fixed with certainty is July 19, 4241 B. C. The calendar year of ancient Egypt consisted of 365 days, divided into twelve months of thirty days each, with five additional intercalary days. The twelve months were divided into three seasons, the inundation, the sowing and the harvest. The first day of the first year was fixed because of the simultaneous occurrence of two extraordinary events, the beginning of the rise of the waters of the Nile and the simultaneous appearance of *both* the sun and the star Sothis (Sirius) on the horizon at the moment of sunrise. This astronomical coincidence is known as the heliacal rising of Sothis, and the phenomenon, known as the Sothic cycle, reoccurs every 1,460 solar years or every 1,461 Egyptian civil years.

In the course of Egyptian history this heliacal rising of Sirius occurred in 4241, 2781, and 1321 B. C., and 140 A. D., but the Egyptian calendar, based on the Sothic cycle, had been in use prior to the IV Dynasty, so that the introduction of the calendar must have antedated 2781 B. C. and accordingly could not have been initiated later than 4241 B. C. The calculations of modern astronomers show that at dawn on July 19, 4241 B. C., in the latitude of Memphis, this heliacal rising could have been observed, and accordingly this is the *latest* date at which the calendar of ancient Egypt could have been initiated. It may have been 1,460 or some multiple of 1,460 years earlier!

My purpose in calling attention to this date is to emphasize the fact that, as early as 4241 B. C., the science of astronomy was highly developed in the early Egyptian civilization.

Let us imagine that the group of scientific men present here to-night could, with all their modern and varied scientific training, by some magic be transported backward through time to Memphis at dawn on July 19, 4241 B. C., and there, facing the eastern horizon, are viewing the rising of the sun. How many would observe that an unparalleled and unrecorded astronomical phenomenon was taking place? Probably the heliacal rising would pass unobserved! And yet the priests of ancient Egypt were sufficiently versed in the phenomena of the heavens to recognize and commemorate this unusual event! The more that the ancient records reveal, the more respect one has for the knowledge possessed by the civilizations of the past.

On the plains of Arizona, near Casa Grande, stands a prehistoric ruin. Built in the form of a double hollow square, one rectangle within another, three stories high, of adobe mud, with walls four feet thick, it probably formed the citadel of an extensive and populous city. The eastern wall of this ruin is pierced by a hole, perhaps two inches in diameter, passing entirely through the

[2] A. Moret and G. Davy, "From Tribe to Empire," p. 134. Alfred Knopf, N. Y., 1926.

four-foot wall of adobe. The wall of the inner room is pierced with a corresponding hole, and at sunrise on March 7 the rays of the sun pass through the hole in the outer wall, stream across the corridor of the outer room, pass through the hole in the four-foot inner wall of adobe, stream across the inner room, and strike the center of a rude cross on the opposite wall. This phenomenon occurs again at sunrise on October 7. Was it a calendar marking the beginning and end of the summer season? The sowing and the reaping? We can only believe it was this, and we can only wonder how a primitive race, in the stone age, could, without modern engineering instruments, construct these two holes, forming essentially a tube some two inches in diameter and perhaps forty feet long, inclined at the exact angle to permit the unobstructed passage of the rays of the rising sun throughout its entire length.

The prehistoric civilization in the Casa Grande valley left no written records, but the country for miles around bears evidence of their culture and industry. One may drive in an automobile for miles on the bottom of their irrigation ditches, in some of which two cars may still drive abreast of each other with walls still rising high on each side. When these ditches are excavated to the original puddled adobe bottoms, and when the transits of the modern irrigation engineer are sighted down them, it is found that they wind across the plain with an almost exactly uniform rate of fall, mile after mile. Dug by stone-age people, with stone implements, and the earth removed in baskets, they are works which challenge the precision of the irrigation engineer of to-day; and the waters of the new Gila River project are, in part, flowing through the cleaned-out irrigation ditches of prehistoric man.

These peoples cremated their dead, and the area where the ashes were deposited is rich with millions of tiny beads, beautifully worked from shell or agate or turquoise. Many of these beads do not exceed two millimeters in diameter and are pierced by a hole so fine that only a human hair can be passed. The fineness of the opening challenges the best skill of the best lapidaries of to-day. How did stone age man accomplish this with stone age tools? That question still awaits solution.

We have only to contemplate the extensive prehistoric irrigation systems of our own Southwest and of the valleys of the Tigris and Euphrates, the achievements of the builders of the pyramids, and of the temples of Baalek, to recognize that the ancient civilizations had progressed a long way in the sciences as applied to engineering problems. But the sciences of those ancient civilizations were largely limited to astronomy, which was probably associated with their religious practices, and to the field of applied physics as related to mechanics. These, with a crude understanding of metallography, provided the basis of their material culture. When, in the course of time, these ancient civilizations were swept aside, a new philosophy dominated scientific thought. Speculation was sufficient, experimentation was unnecessary, and through much of the Greek and Roman eras and down through the middle ages, the speculative writings of the philosophers held scientific progress in abeyance. The dreams of the dreamers were accepted as authoritative.

Modern science and modern civilizations differ from those of the ancients in that all the natural sciences are emphasized and in that experimentally demonstrated facts are demanded. Extensive and intensive research is systematically prosecuted in all directions, and new scientific facts are hardly announced by their discoverer before some utilitarianly-minded person incorporates them into the structure which modern man is building for his aggrandizement, comfort, or convenience.

Which, perhaps, brings us to the question, "What is science?" The uninitiated and uninformed often define it as "the organized body of facts relating to natural phenomena," a definition which implies a degree of finality which the true scientific man is unwilling to assume.

I am willing to grant that there *appears* to be a large measure of finality in what we accept as fundamental scientific principles, but as a scientific man I should not at all be surprised if even some of these "scientific principles" should ultimately be shown to be only crude approximations, or be wholly replaced by new and more fundamental conceptions. The demonstrator of a new fact is often the executioner of an old theory, and a theory is of value only in so long as it is supported by the facts.

Unfortunately the layman does not always recognize the truth of this statement, and often assumes that the theories of the scientific man, because they are stated as theories, are without a factual basis. We have witnessed in the past few years the attempts of those ignorant of scientific facts to legislate against scientific theories. Perhaps no more fitting reply can be made to them than was made by President Coffman, of the University of Minnesota, when, speaking before the Legislature of the State of Minnesota in opposition to an "anti-evolution" bill, he turned the tables upon his opponents and pointed out that even in the field of religion there has been an evolutionary progression. President Coffman[3] said:

The spirit of America will wither and decay when the correctness of scientific theories is decided by legislation or by the counting of heads. If that method had been followed in the past as is proposed to-day, we should be meeting to-night clothed in the skins of beasts we had killed by bows and arrows. Squatted around a campfire in a cave we should be trying to decide whether to burn or behead some member of our tribe who said that the god of the harvest was greater than the god of the hunt.

By a long, upward trail, by trial and error, in sending to the stake or the rack those who were eager to know the truth and to explain it, the human race has come to cherish learning and support the labor of scholars. It no longer drags learners before courts and throws men who are seekers of truth into dungeons. It has done wiser and better things. It has founded schools and colleges and universities. In these it has gathered the scholars and thinkers who can find better ways than our fathers knew and teach them to our children. It is to the scientists or the expert in any line that we turn for an answer in scientific matters. We know that he must be free to find the facts as best he may and equally free to seek a theory or hypothesis that explains them. If there is error in his deductions, there is only one way that it can be shown and that is by his own ceaseless and unimpeded search and the labors of his fellow scientists. Mistakes may be made, but unrestricted research is the only means by which they can be corrected. If we are to have better science, we can not get it by legislative decree but by giving teachers and investigators the utmost freedom. If those who know most can not discover and correct error, we who know less can not help by majority votes or minority clamor.

Only a scientific man fully appreciates how quickly a theory is swept into the discard when new scientific facts incompatible with that theory are discovered. There hangs upon the wall of my office a motto clipped many years ago from some advertising literature. It reads: "It's the fellow that doesn't know any better that does the thing that can't be done. You see, the blamed fool doesn't know it can't be done, so he goes ahead and does it." That motto has encouraged me more than once to attempt to proceed along paths which were apparently barred by some particular theory, and to attempt to differentiate more sharply between scientific theory and scientific fact.

The chemistry which most of us studied in our undergraduate days was vastly different from the chemistry of to-day. Then the atom was a round, hard ball, the ultimate unit of matter, in-

[3] L. D. Coffman, "The Teaching of Evolution," *School and Society*, 31: 754–758. June 7, 1930.

divisible, non-transmutable. How we smiled at the ignorance of the alchemists who believed in the impossible—the transmutation of the elements! To-day all this is changed. The atom was yesterday a solar system, mostly empty space with a tiny but heavy nucleus of closely packed protons and electrons surrounded by a cloud of electrons moving in fixed orbits with a speed approximating that of light. To-day we are not sure that either electrons or protons exist as definite entities, they may be only waves of energy. Matter as such may be only a localized manifestation of some special form of energy. Even the fundamental concepts of the conservation of matter and of energy have undergone radical changes within the last two decades, and we now believe that matter and energy are interconvertible. The transmutation of the elements in the scheme of nature is a proven and universally accepted fact; and the dream of the alchemist of a *forced* transmutation has been accomplished in the laboratory. Those of us who have lived through these revolutionary discoveries may well wonder what new conceptions the future will bring forth.

The tremendous increase in knowledge in the physical sciences during the last hundred years has made possible the material civilization in which we live today. The material aspects of our grandfather's civilization were closer to those of the civilizations of ancient Egypt and Assyria than are the material attributes of our civilization—a hundred years later—to those of our grandfathers.

Contrast, if you will, 1832 and 1932; soft soap made by the housewife from the hardwood ashes of the fireplace and the fat dripping from the kitchen, and to-day the equipment of a single modern manufacturer of more than eighty kettles each holding 50,000 pounds of fat; then candles for lighting, now the gas-filled bulbs; then largely homespun dyed with natural pigments, now rayons, silks and fine fabrics in all colors of the rainbow are accepted as a matter of course; then wooden buildings were put together largely with wooden pegs because of the expense of hand-wrought nails, now the steel frames of our skyscrapers are welded into a single piece of metal; then surgery without anesthetics, medicine without antiseptics or the modern synthetic drugs, transportation by horseback or stage-coach, but why go on? The average farm home of to-day is luxury itself as compared with the middle-class home of only a hundred years ago.

Our present rapid progress in material conveniences is due to the fact that we have accepted the scientific man as being capable of doing the impossible! In 1844 the world was electrified when the message, "What hath God wrought?" was tapped out over a wire stretched between Baltimore and Washington, and in 1927 New York flashed a *spoken* message *without wires* across the ocean to London!

It was my good fortune to be present at the international air races at Mineola, Long Island, on October 27, 1910. A prize of $10,000 had been posted for that pilot who would fly his plane fifteen miles to the west, circle the Statue of Liberty, and return to the field without landing. Plane after plane disappeared in the distance, but none returned! The last plane was wheeled out, and it carried the American flag. It took off, disappeared and later it reappeared again high in the western sky and coasted to a landing on the field. The prize had been won for America, and the burst of enthusiasm from the crowd is one I will long remember. And the sequel came only seventeen years later when Lindbergh flew alone from New York to Paris!

An editorial[4] in a recent scientific journal beautifully expresses the casual

[4] *Ind. Eng. Chem.*, 22: 205 (1930).

acceptance of the achievements of the scientific man. It reads as follows:

Some indication of what we have come to expect as a result of the past achievements of science is to be found in the attention given in the daily press to what would have been considered as impossibility a brief decade ago.

A representative of Admiral Byrd required an immediate decision in New York. The admiral's representative, seated at a telephone, communicated with the operators of the radio room of the *New York Times* and dictated the messages he wished to transmit to the admiral in Little America, emphasizing the urgency of an immediate acknowledgment. Imagine his surprise to be told laconically to hold the phone, and overhear the operator explain that the messages must be put through for an immediate answer—"he is holding the wire." While the wire was held these messages went through to the Antarctic, nine thousand miles away, and in less than five minutes the operator reported "Lofgren (Admiral Byrd's secretary) says hold on a minute or two. Byrd is replying."

In twenty minutes from the time of the first telephone conversation, Admiral Byrd had made his reply to his representative and he had hung up. Of course the conditions were favorable at the time and everything possible was done to facilitate the sending and the receipt of the messages. Nevertheless, to us it is one of the many modern miracles.

Now where do you suppose such an important bit of news finds a place these days? On the fifteenth page, section 1, of a metropolitan daily. Such accomplishments are no longer front-page news; the public has come to expect so much of science.

And the civilizations of the future—will they follow the trends of the civilization of to-day? Will the complexities of life increase in geometric ratio with the passing of each decade? Will the wheels of our industrial life turn ever faster and faster, until a hundred or even five-hundred years from now an individual will, in a ten-year period, meet as many problems, see as many accomplishments, achieve as many results, as we meet, see or achieve in our lifetime, just as we in a ten-year period to-day live a lifetime of our grandfather's day? The answer to this question can be given almost with finality. Probably not! The wheels of industry *must* inevitably slow down, not necessarily for the reason that man can not mentally or physically stand up under the increased tension of an ever-increasing complexity of life, but rather because our modern materialistic and industrial civilization has so changed our natural environment as to limit the possibilities available to future generations.

The great civilization of ancient Egypt arose in the valley of the Nile, a region almost devoid of mineral resources. Early in its history Egypt asserted hegemony over the Sinai peninsula, for there copper could be obtained. Metallurgy probably had its origin in this region, and there we can still see the mining galleries, the crucibles which were used for smelting the ore and the heaps of slag which resulted. The carved inscriptions of Egyptian monarchs, boasting of their wealth and power, remain cut in the living rock, but the sound of the pick and the sledge is forever stilled, and only the nomad roams over the desert waste, for the copper ore, placed there by natural forces uncontrollable by man, is gone.

The history of ancient Egypt is replete with wars, not of conquest, but wars waged against those who threatened the domination of Egypt over this copper-bearing area. The Egyptian state acquired the copper mines on Sinai about 3300 B. C., and this natural resource transformed the material and industrial life of ancient Egypt. Her supremacy in the ancient world remained, essentially unchallenged, for approximately 2,000 years, until the copper ore was exhausted about 1500 B. C. Then she fell before the onslaught of the Hyksôs, the Hittites and the "Peoples of the North," hordes which swept out of the north with weapons of bronze and iron, mounted on horses or riding in terrible war chariots drawn by horses. Better weaponed and more mobile than the Egyptians, who were not acquainted with iron and who knew only the ass, the culture of ancient Egypt was overwhelmed by the barbarian. Was it only a coincidence that the state of ancient

Egypt came to an end at approximately the same time that her resources in the form of metal-bearing ores were exhausted? The stone age gave way to the bronze age. The bronze age fell with the advent of iron and steel. The man with the club could not cope with the man with the sling. The slinger fell before the archer. Gunpowder again changed the maps of the world. Inventive genius and available natural resources even to-day determine whether a nation shall survive or perish.

The records of early man are few and indistinct. Perhaps a half a million years of progress were necessary before he reached the stage where a written language was developed. The written records which were left by these early civilizations, and which seem so old and strange to us, are only yesterday's news items in the history of mankind.

Malthus in 1798 called attention to the fact that populations increase with time not in an arithmetical but rather in a geometrical ratio, and it is now rather generally accepted that most generalized biological responses, such as growth rates, form sigmoid curves; each successive increment being slowly added at first, then faster and faster until, when maturity is approached, the rate gradually slows down and eventually becomes stationary. In so far as the *possibilities* of applied science are concerned, we are probably close to the bottom of the steep portion of a sigmoid curve, and *a priori* we may assume that applied science will accomplish greater and greater achievements with greater and greater frequency as the years unfold. Such an assumption, however, presupposes a *normal* curve, just as a normal growth rate assumes health, adequate nutrition and the other factors of an optimum environment. No one will question the health of the infant, "Applied Science," but careful thinkers have already raised disturbing questions in regard to its future nutrition. In the last hundred years this lusty infant has increased its food consumption perhaps a thousand fold, and, unfortunately for mankind, already the shelves in some of nature's cupboards show signs of exhaustion of specific food supplies.

All that applied science has as yet done for man is to adapt to man's use certain of the natural resources of man's environment, and in many instances these natural resources, on which our modern industrial civilization is absolutely dependent, show probabilities of exhaustion in the almost immediate future. Jaeger[5] has summed up in a terse paragraph the problem that faces us.

> Techniques and industry in their present aspect would be obliterated if the natural resources of supply of such metals as iron, copper, tin, lead, zinc, etc., should suddenly become completely exhausted. Dynamo and steam engine would in that case irrevocably disappear, just as the monsters of earlier geological epochs, the ichthyosaurus and the megatherium, vanished as soon as conditions became incompatible to their existence. Industry and traffic in their present form would become quite impossible. And the same is true, if the stores of coal and oil were no longer at our disposal. Attention has repeatedly been drawn to the fact that the danger of such a catastrophe is not very remote if we continue to squander our capital of raw materials in the reckless way that has been pursued in the past and indeed is even now being followed.

And the stores of copper, antimony, tin, lead, zinc, chromium, manganese, nickel, iron, oil and coal stored in that portion of the lithosphere which is accessible to man will probably be exhausted in less than one thousand years if used at their present rates of consumption, and the rate of consumption in some instances is doubling with the passage of each decade! Read[6] notes that, "There is not a single mineral sub-

[5] F. M. Jaeger, "The Present and Future State of Our Natural Resources," *Science*, 69: 437–445, 1929.

[6] T. T. Read, "Our Mineral Civilization," Williams and Wilkins Company, Baltimore, (1932).

stance of which the quantity used in the past century is less than the total of all the centuries that preceded."

Through untold millions of years these natural resources have been accumulating here and there in isolated areas near the surface of the lithosphere. Through tens of thousands of years man has been slowly differentiating from the other forms of the animal kingdom. Suddenly —within the last hundred years—he has had placed in his hands the tools of science, and with them he has already wrested from the earth from 10 to 50 per cent. of the natural resources which are there available, has enjoyed them for a moment, and then, either destroying them or casting them aside in a form useless to coming generations, he has turned with an ever-increasing vigor to the task of further depleting the potential supply.

We send our fellow men into the bowels of the earth to dig for iron. Other fellow men labor in the heat of the furnace, where enormous amounts of energy from coal and oil are expended, to produce the steel. By a further expenditure of man power and energy the steel is fabricated into battleships and weapons of war, and, in a few years, when these become obsolete, they, serving as targets for newer battleships, are sunk forever in the oceans. In the oceans and lakes, and along the highways and byways of the countryside, the frames of America's old automobiles are rapidly rusted away. Thousands upon thousands of tons of metal are cast aside after man has played with it for a brief moment, and, unfortunately, cast aside in a form which makes it unavailable to generations yet unborn.

In spite of the fact that the world's resources of tin are exceedingly limited, we still demand tinfoil around candy bars and packages of cigarettes, and the world's available sulfur supply is being rapidly exhausted in the demand for cellulose products which have a silken sheen. Such illustrations could be extended almost indefinitely. I have called it a "modern civilization." Viewing our wastage of natural resources, I sometimes wonder if we are civilized.

It has been estimated that the iron of Germany will be exhausted in forty to fifty years, that of Scandinavia and of the United States in less than one hundred years, that of Russia in less than one hundred and fifty years, and that all the iron mines of the world will be mined out at the present rate of mining in less than two hundred and fifty years. The copper, zinc, lead and tin resources of the world will be exhausted long before the iron is gone!

Taylor[7] has recently studied the sulfur problem. The world resources of elemental sulfur approximate 120,000,000 metric tons, of which the United States has the largest single supply of approximately 40,000,000 metric tons. At its present rate of use the American supply will be exhausted in *fifteen* years! And the world supply, including 450,000,000 metric tons as available from pyrites, will last the world at the present rate of usage not to exceed one hundred and fifty years!

Binz[8] has considered these problems in an illuminating fashion. He points out that the energy resources of the world will far outlast the metallic resources, but that even the energy resources are extremely limited. These resources represent the radiant energy sent out from the sun through bygone geologic ages and fixed by plants through the agency of photosynthesis. Stored in the earth in the form of coal and oil they constitute the energy source for our modern industrial civilizations, and the energy reserve for the civilizations which are to follow. At the present rate of consumption the coal of England

[7] A. M. Taylor, "Economic Position of Sulfur," *Ind. Eng. Chem.*, 24: 1116, 1932.

[8] A. Binz, "Chemie, Technik, und Weltgeschiete," *Z. angew. Chemie*, 40: 449–455, 1927.

will last about fifty years, that of France less than three hundred years, that of Belgium less than eight hundred years, that of Germany less than a thousand years and that of the United States, including our vast lignite deposits, less than fifteen hundred years.

The chances of man finding another energy source which will replace that which we now secure from coal and oil is exceedingly remote. Transeau[9] has rightly pointed out that if all the corn grown in America, including grain, leaves and stalks, were converted 100 per cent. into alcohol, the energy so made available would not equal that necessary to operate the automobiles which we operate on gasoline to-day. And the corn plant is one of the most efficient plants in the fixation of solar energy!

Energy derived from available water power of our inland streams would be utterly inadequate in amount. Solar mirrors, tide machines, and the like can be dismissed as an improbable ultimate solution of the energy problem, for iron and other metals necessary for the construction of such equipment will no longer be available in quantity when the need arises. If all the iron which we utilize to-day were to be utilized solely for the construction of mirror frames and solar engines, and if each year's output of iron were added to such construction, and the solar mirrors and engines were placed in a tropical cloudless region, we should still find that our present energy demand had not been met.

Binz suggests that the temperate zone where our industrial civilization is now most highly developed may, when our energy supplies are exhausted, become uninhabitable. That man will again be limited to the tropics and the subtropics where snow does not fall, and then, if that be the case, in this, their more favorable environment, the brown, black and yellow races will come into their own.

Perhaps the picture has been overdrawn. Perhaps the colors are too lurid. Perhaps other virgin supplies, unknown to man to-day, exist in unexploited regions. Perhaps the date of exhaustion may be moved another thousand years into the future. A thousand or five thousand years? It is but a moment in the history of mankind!

Has the applied science of the white man raised up a Frankenstein which will ultimately destroy him, or will the scientific men of the future solve these problems which appear to us insoluble? Will future civilizations look back upon the industrial civilization of the twentieth century not as an age of progress but rather as an age of despoilation, as to-day we look back upon the Tartars and the Vandals and the Huns who destroyed the civilization of Greece and Rome? Will the wheel of time turn man backward to a more primitive and isolated existence, with the horse and the wooden sailboat again his only means of transportation?

These are questions which can not be answered now. Only the historians of future generations can answer them, but we can assert, with a high degree of finality, that the civilizations of the future will be vastly different from the civilization of to-day; and that if the upward progress of mankind is not to slacken or to fail altogether, the scientific men of the future must solve infinitely more difficult problems than those which face the scientific men of to-day.

Yesterday, to-day and to-morrow! We are here! We know somewhat from whence we came, we know not whither we are going.

[9] E. N. Transeau, "The Accumulation of Energy by Plants," *Ohio Jour. Sci.*, 26: 1–10, 1926.

# LIQUIDATION AND REHABILITATION OF THE CONSUMER AND SMALL BUSINESS

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THE tremendous economic and social waste involved annually in the failure of firms and individuals is illustrated by the recording in the fiscal year ending June 30, 1931, of more than 60,000 bankruptcies alone, involving in excess of one billion dollars of liabilities. The increase in obligations is about 9 per cent. annually of the average for the period 1911 to 1931.

Similarly, the annual increase in the number of bankruptcies in the northern district of Illinois is 5 per cent. of the average for the period 1916 to 1931, while the average increase in liabilities is 8 per cent. In the last four years, the New York district has accounted on an average for about 38 per cent. of the total bankruptcies of the United States and about 10 per cent. of the total liabilities, while the northern district of Illinois has approximated 33 per cent. of the total number and 5 per cent. of the total liability.

Using the average volume for the years 1923 to 1925 inclusive as the base, or 100 per cent., in each case, Chicago bank clearings fell from about 113 per cent. in 1929 to 88 per cent. in 1930 and 59 per cent. in 1931. In the same period, commercial failure liabilities of the Seventh Federal Reserve District, centered in Chicago, rose from about 96 per cent. in 1929 to 145 per cent. in 1930 and 178 per cent. in 1931. At the same time, liabilities in closed bankruptcy cases in the northern district of Illinois dropped from 195 per cent. in 1929 to 162 per cent. in 1930, and then rose to 175 per cent. in 1931. However, for the period 1880–1925, Carl Snyder[1] calculated that the relation of liabilities to bank clearings outside New York City declined from about $4,000 of liabilities per $1,000,000 of bank clearings to an average of about $1,000 liabilities to $1,000,000 of bank clearings. In the same period the number of firms failing increased at about the same rate as population and the number of firms in business.

[1] "Business Cycles and Business Measurements," pp. 182–183.

It is important to consider failure not as a depression phenomenon, but as a chronic disorder in our economic system.

The problem affects the stability of the debtor family, the welfare of the creditor, and the functioning of the economic process.

In seeking insight into the problems and factors of insolvency and rehabilitation, analysis was made in the Chicago area of liquidation by bankruptcy, assignment and receivership, of stabilization by creditor and cooperative management, of methods used by going concerns to meet current problems and of processes and agencies of recuperation. Methods employed include statistical and case analysis. Interviews were held with the failed individuals and representatives of corporate firms, and contacts were established with creditors and competitors, and in some instances with customers and neighbors. Surveys were made of neighborhood conditions, including vacancies and unemployment, while going concerns in the same areas and fields of business were studied as controls. Only bankruptcy cases are considered in this report.[2]

[2] Though collection of bankruptcy data was in collaboration with the United States Department of Commerce, represented by Mr. Victor Sadd, analyses and inferences are exclusively the responsibility of the author.

### Business Failures

Analysis of factors influential in the failure of business concerns indicates that about one half of the individual proprietors failed because of discernible errors in management, and that an additional one fourth succumbed to environmental conditions over which they had no control. One tenth of the proprietors suffered reverses due largely to family affairs, such as illness, while one fourteenth sacrificed their regular business to the whims of speculation. In Table I, the principal factors are indicated in their relative importance.

TABLE I

Principal Factors in Failure of Individual Proprietors in Retail Business

| Factors | Number of cases | | Per cent. of cases | |
|---|---|---|---|---|
| Management: | 199 | | 50.13 | |
| Capital: | 26 | | 6.54 | |
| Inadequate at organization | | 12 | | 3.02 |
| Mortgage | | 2 | | .50 |
| Fixtures and equipment | | 12 | | 3.02 |
| Overhead | | 48 | | 12.09 |
| Credit extension | | 18 | | 4.53 |
| Expansion | | 15 | | 3.78 |
| Location | | 22 | | 5.54 |
| Experience | | 28 | | 7.05 |
| Negligence | | 11 | | 2.77 |
| Endorsing notes | | 6 | | 1.51 |
| General incompetence | | 25 | | 6.30 |
| Environmental conditions: | 109 | | 27.45 | |
| Competition: | 70 | | 17.63 | |
| Price | | 15 | | 3.78 |
| Chain | | 37 | | 9.32 |
| Other | | 18 | | 4.53 |
| Neighborhood changes: | 39 | | 9.82 | |
| Highway obstruction | | 2 | | .50 |
| Migration | | 2 | | .50 |
| Closed factories | | 12 | | 3.02 |
| Closed banks | | 4 | | 1.01 |
| Inventory deflation | | 10 | | 2.52 |
| Burglary or fire | | 9 | | 2.27 |
| Family affairs: | 39 | | 9.82 | |
| Medical expenses | | 13 | | 3.28 |
| Illness of bankrupt | | 9 | | 2.27 |
| Extravagance | | 9 | | 2.27 |
| Dependents | | 8 | | 2.02 |
| Personal characteristics | | 8 | 2.02 | 2.02 |
| Speculation: | 29 | | 7.30 | |
| Real estate | | 24 | | 6.04 |
| Stock | | 5 | | 1.26 |
| Miscellaneous | | 13 | 3.28 | 3.28 |
| Total | | 397 | 100.00 | 100.00 |

The largest item of mismanagement is the failure to control overhead expenses. Business rent was the most frequent difficulty in this category. Proprietors signed lease contracts in anticipation of large business volumes which never materialized. Landlords, impelled by the apparent advantage to them of the contract or by a joint understanding as to rent levels in particular locations, were reluctant to yield.

Among environmental factors chain store competition was dominant. The chain store in most instances has been characterized by lower costs (including rentals), reduced consumer prices of many commodities, and more modern business facilities. However, it is not apparent that the chain store as an institution is eliminating the best of the individual proprietors. It would appear that most of the failures occurred to marginal firms, parasitic in nature, which could remain in business only so long as not challenged by pressure of economic forces or of modern business methods.

Real estate venture greatly outweighed security speculation as a factor in the failure of proprietors.

Under management, three problems of capital have been differentiated. In twelve instances proprietors attempted to establish their concerns with inadequate reserve; a few proprietors even brought to the new business an indebtedness incurred in a previous failure. In two cases the mortgage burden was a millstone precluding all possibility of floating the business. Capital problems of fixtures and equipment include primarily over-investment, but in a few cases inadequate facilities for operation.

Location is a site value with respect to consumer patronage as contrasted with neighborhood conditions, an environmental factor. In twenty-two cases the inauspicious location of the store made success improbable, and in almost all such cases no effort was made to evaluate the location before establishing the business.

A distinction is made between experience, which refers to practice in the particular field, and general incompetence, which infers lack of ability and judgment in the conduct of business. The latter category, of course, has an arbitrary standard of judgment. Only such cases were entered in this group as indicated recurrent mismanagement in various phases of business. For instance, if a proprietor extended credit beyond safety, withdrew from the business for personal use funds considerably in excess of a warranted proportion, and, in addition, was uncivil to customers, he was forthright relegated to general incompetence.

In several neighborhoods of the city of Chicago, distinct migrations are apparent—racial, national or economic. A proprietor whose business over a period of years has been attuned to a particular clientele may find himself confronting adjustment to a new group of customers. Such changes are frequently difficult not alone because of personal habit but, even more significant, because of group customs and animosities.

Inventory deflation is a frequent experience in all business, but becomes a formidable factor with the appearance of new inventions or sudden changes in style. Decreased demand for musical instruments with the advent of radios is an illustration of the first group, changes in the length of women's skirts, of the second.

By extravagance is meant uncontrolled expenditure in excess of income without regard for budget relationships. An expenditure for residence rent aggregating 30 per cent. of the annual income was considered excessive. On the other hand, emergency medical expenses which normally would not be included in the budget did not relegate a family to this category. Such an emergency expenditure was classified as a separate factor, "medical expenses."

In eight instances support of relatives who previously had been independent added a burden which the business could not maintain.

Another category of arbitrary judgment is designated "personal characteristics." In this group are several illiterate persons whose chances of success even in the neighborhoods of lowest standards of intelligence seemed exceedingly small. In a few instances, repugnant personality seemed to be a large factor in failure as gauged by the interviewer's estimate and by inquiry in the neighborhood in which the person operated.

In the miscellaneous group as included primarily cases in which a strong suspicion of irregular practices or fraud was present, without evidence that could be accepted by a court. Case studies divulged no other factors which would seem to account for the bankruptcy of this group.

Contributory causes, secondary to principal factors in importance, are recorded in Table II. Again, the predominance of errors in management, particularly with reference to capital and overhead control, are impressive. Since several contributory factors are frequently associated with one principal factor, the total number of causes involved in Table II is in excess of the totals of Table I.

There is little evidence of correlation among primary and secondary factors. For instance, chain-store competition is a principal factor in the failure of 13 of the total of 41 grocery stores. Asso-

TABLE II

CONTRIBUTORY FACTORS IN FAILURE OF INDIVIDUAL PROPRIETORS IN RETAIL BUSINESS

| Factors | Number of cases | Per cent. of cases |
|---|---|---|
| Management: | | |
| Capital: | | |
| General | 61 | 9.26 |
| Mortgage | 25 | 3.79 |
| Fixtures and equipment | 10 | 1.52 |
| Loan and finance company loans | 4 | .61 |
| Overhead | 85 | 12.90 |
| Credit extension | 12 | 1.82 |
| Expansion | 5 | .76 |
| Location | 25 | 3.79 |
| Experience | 46 | 6.98 |
| Negligence | 20 | 3.04 |
| Endorsing notes | 2 | .30 |
| General incompetence | 44 | 6.68 |
| Environmental conditions: | | |
| Competition: | | |
| Price | 14 | 2.12 |
| Chain | 35 | 5.31 |
| Other | 46 | 6.98 |
| Neighborhood changes | 49 | 7.43 |
| Inventory deflation | 9 | 1.37 |
| Burglary or fire | 5 | .76 |
| Family affairs: | | |
| Medical expenses | 25 | 3.79 |
| Illness of bankrupt | 14 | 2.12 |
| Extravagance | 6 | .91 |
| Number of dependents | 26 | 3.95 |
| Personal characteristics | 26 | 3.95 |
| Speculation: | | |
| Real estate | 14 | 2.12 |
| Stock | 4 | .61 |
| Creditor pressure | 6 | .91 |
| Miscellaneous | 41 | 6.22 |
| Total | 659 | 100.00 |

ciated as auxiliary factors are the following: neighborhood conditions, 4; lack of experience, 4; capital problems, 2; general incompetence, 2. Similarly, with inexperience, which occurs 4 times, are associated lack of capital, 2; chain store competition, 2; and one each of the following: overhead, poor location and illiteracy.

In the case of grocers, again, inexperience occurs as an auxiliary factor 9 times, associated with the following: chain store competition, 4; and one each of the following: credit extension, capital problems, neglect of business and excessive overhead. Capital problems, appearing 8 times as a subsidiary factor, is associated twice with chain store competition, twice with inexperience, and once each with negligence, real estate speculation and excessive overhead, as principal factors.

In the drug and restaurant fields, there was no concentration of causes. Chain store competition appears most frequently in the case of the drug field, but only in 5 of a total of 28 cases. With restaurants, inexperience of operators was the most frequent in occurrence, but again in only 5 of a total of 29 cases.

Similar scatterings of factors occur in men's wear, women's wear, dry goods and other clothing.

## CONSUMER FAILURES

Of 411 personal failures, 72, or 17½ per cent., though employees for at least the previous year, had once been business proprietors and had sought bankruptcy largely because of the pressure of obligations incurred in this earlier status. Though family incomes, expenditures and assets of this group are comparable to the consumer group in general, liabilities, both in volume and character, require separate consideration. It is not surprising to find about 31 per cent. of the salespersons represented in this special group, but to discover that 9 per cent. of the laborers were involved is a fact of social significance. As disclosed later, large groups of proprietors failing in business have recourse to some form of labor which many of them hoped would be only a transitory occupation.

Unwarranted excess of expenditures over income, "living beyond income," is the principal factor in the failure of 17½ per cent. of all personal bankrupts. It is effective similarly in the case of 22 per cent. of the salespersons and 14 per cent. of the laborers. This factor was

referred to as "extravagance" in business failure categories. In establishing norms as bases for judgment, incomes and expenditures were considered both in the absolute and in relation to each other. Emergency expenditures, such as expenses of illness, did not relegate a family to this category. A contractual expenditure, such as residence rent, was considered not alone relative to the income of the twelve months preceding failure but, in addition, to the income of the second year previous in order to correct for possible income decreases.

Sudden decreases in salary, sufficiently large relatively as to prevent immediate readjustment, entered as a separate category in 2 per cent. of the cases.

Speculation plays relatively a large part in the bankruptcy of several occupational groups. The interest in real estate is noticeable. By "home speculation" is meant the assumption of interest and amortization obligations in the purchase of a residence far beyond the possibilities of income, considering other liabilities as well.

A summary of principal factors in personal bankruptcy is provided in Table III.

Included in the miscellaneous category are gambling, betting, automobile accidents and liabilities, frequent intoxication, bank failures, insolvency of bankrupt's debtors, and similar items.

Of 21 salespersons who failed largely because of extravagant living, excessive retail credit was associated in 10 cases, and instalment purchases in 8, and salary decreases in 8 others. Subsidiary causes associated with these 21 cases numbered 48.

In 9 cases in which real estate speculation was a principal factor, only once does stock speculation appear as a contributory factor. However, in 10 cases with stock speculation as a chief factor, real estate speculation occurs 3 times as auxiliary.

TABLE III

PRINCIPAL FACTORS IN PERSONAL BANKRUPTCIES

| Factors | Number of cases | | Per cent. main groups | Per cent. subgroups |
|---|---|---|---|---|
| Debts from former business | | 72 | 17.52 | 17.52 |
| Living beyond income | | 72 | 17.52 | 17.52 |
| Speculation: | 81 | | 19.71 | |
| Real estate | | 41 | | 9.98 |
| Stock market | | 16 | | 3.89 |
| Home | | 24 | | 5.84 |
| Employment: | 48 | | 11.67 | |
| Part-time | | 19 | | 4.62 |
| Unemployment | | 29 | | 7.05 |
| Illness: | 45 | | 10.95 | |
| Bankrupt | | 17 | | 4.14 |
| Family | | 22 | | 5.35 |
| Death | | 6 | | 1.46 |
| Dependents: | 11 | | 2.68 | |
| Own | | 5 | | 1.22 |
| Relatives | | 6 | | 1.46 |
| Signing notes | | 23 | 5.60 | 5.60 |
| Family difficulties | 15 | | 3.65 | |
| Divorce | | 10 | | 2.43 |
| Excessive rent | | 0 | | |
| Other | | 5 | | 1.22 |
| Decrease in salary | | 10 | 2.43 | 2.43 |
| Miscellaneous | | 34 | 8.27 | 8.27 |
| Total | | 411 | 100.00 | 100.00 |

## FAMILY INCOME

While incomes of the families of individual proprietors show a concentration centered at about $1,300, the interval from $1,200 to $1,399 includes only approximately 10 per cent. of those cases for which data were available. Within the range $1,000 to $1,599 is found slightly more than one fourth of the total. However, there are five other intervals, each of which exceeds 6 per cent. of the total; 3 of these are close to 8 per cent. Dividing the number of items into fourths, the first quartile value is $1,284, the median, $2,004 and the third quartile, $2,763.

Similarly, although family incomes of

personal bankrupts indicate a concentration at approximately $2,000, the dispersion records many large frequencies in other income classes. There are forty-three cases in each of the intervals, $1,800 to $1,999, and $2,000 to $2,199. The minimum and maximum frequency of the five class intervals between $800 and $1,799 are twenty-one and thirty-two. Twenty-one incomes range between $6,050 and $20,000, seven of these $10,000 or higher. The quartile values are as follows: first, $1,324; median, $1,949; third, $2,617.

Comparing the two dispersions, the following facts are pertinent: the median incomes differ by fifty-five dollars in favor of the business bankrupts. The differences between the first and second quartiles, and between the second and third, respectively, for the business group are $720 and $759, and for the personal group, $625 and $668, indicating a fair degree of regularity. Consequently, there is little difference in the income classes represented by the business and consumer groups, the former withdrawing compensation from the firms of which they are proprietors, the latter, as employees, receiving salaries and wages.

TABLE IV
PERCENTAGE BUSINESS RENT OF TOTAL SALES

| Type of business | All known cases | | | Excluding "no rent" cases | | |
|---|---|---|---|---|---|---|
| | Number of firms | Median | Mean | Number of cases | Median | Mean |
| Drugs | 35 | 16.5 | 25.0 | 35 | 16.5 | 25.0 |
| Restaurants | 33 | 13.8 | 16.0 | 33 | 13.8 | 16.0 |
| Men's clothing | 38 | 19.4 | 25.5 | 36 | 20.0 | 27.0 |
| Women's clothing | 68 | 13.5 | 19.4 | 68 | 13.5 | 19.4 |
| Total clothing | 135 | 15.3 | 21.8 | 133 | 15.6 | 22.1 |
| Food | 99 | 9.5 | 13.0 | 99 | 9.5 | 13.0 |
| Hardware | 18 | 15.0 | 22.5 | 18 | 15.0 | 22.5 |
| Furniture | 22 | 19.0 | 26.7 | 22 | 19.0 | 26.7 |
| Total retail | 542 | 14.3 | 22.6 | 532 | 14.6 | 23.0 |
| Manufacturing | 137 | 5.8 | 9.5 | 136 | 5.9 | 9.6 |
| Wholesaling | 35 | 4.1 | 6.5 | 31 | 4.7 | 7.3 |
| Miscellaneous services* | 109 | 10.0 | 23.3 | 89 | 15.5 | 28.7 |
| All bankrupt | 823 | 11.9 | 19.3 | 788 | 12.6 | 20.0 |

* Professional, Miscellaneous Proprietor, Contractor and Realtor.

### EXPENDITURES

Although the income of the business group is not high as a whole, the percentages which personal withdrawals are of the total sales of the particular business are both an excessive drain upon the business and relatively higher than the norm found in going concerns of the same type of business. The same is true of rentals paid for business accommodation. In Table IV are recorded for various business fields, central values of ratios of rent to annual net sales.

The following summary records for solvent concerns the range of ratios of rent to net sales for six types of business. The stores used as controls and recording these rents in the period for which failures were studied, though handicapped by depression conditions, showed evidence of ability to continue as "going concerns."

| Kind of business | Range, rent as per cent. of sales |
|---|---|
| Drug | 4.7– 8.8 |
| Grocery | 6.0–10.0 |
| Men's clothing | 9.0–14.0 |
| Women's clothing | 6.0–10.0 |
| Women's specialty shops | 10.0–15.0 |
| Hardware | 10.0–12.0 |

Nineteen per cent. of the personal bankrupts expended for residence rent from 30 per cent. to 34.9 per cent. of their total incomes. The median ratio was approximately 31 per cent., the first quartile, 21 per cent., and the third quartile, 39 per cent.

Approximately 53 per cent. of the personal bankrupts spent 30 per cent. or more of their incomes for residence

rent; the proportion of cases with this rent ratio was slightly exceeded by the business group. If we assume from 20 to 25 per cent. of the income as an adequate allowance for rental, both the business proprietor and employee bankrupts have been excessive in this branch of their expenditures.

Expenditures for illness were analyzed for 427 of the personal bankrupts. Twenty-three per cent. of this group had no medical or dental expenditures in the year preceding bankruptcy. While the average expenditure for those having illness in the family was $395 in the twelve-month period, and while 23 families had expenditures of $1,000 or more, the arithmetic average does not give a valid picture of the problem due to the weight of a small number of large values.

Selecting a concentrated group with medical expenses of less than $1,000 annually and with income of less than $4,800, it is found that more than 45 per cent. of the families had spent less than $200 for medical care, and almost 53 per cent. had expenditures less than $250.

Again, while the mean ratio of medical expenses to total income is 20.4 per cent., the modal ratio, representing approximately 23 per cent. of the total number of families, is only 2.5 per cent. Of the 54 families with medical expenses 25 per cent. or more of their total annual income, 44 had incomes of less than $2,600. Of the 13 families with medical expenditures of 50 per cent. or more of income, 10 had incomes of less than $2,200.

Therefore, while the bankruptcy group as a whole was not seriously affected by medical expenses, a significant proportion had its solvency jeopardized by illness.

### Assets and Liabilities

Until disposed of by sale, available asset evaluations are the estimates of the bankrupts and of the court. Usually the bankrupt's appraisement is optimistic, based upon his desire to make a good showing as well as upon his recollection of original cost and his estimate of replacement value. On the other hand, the court estimate usually is affected by the expectation of forced sale. The bankrupt's evaluation is the first available since it is a part of his bankruptcy petition. The income received from disposal of the bankrupt's equities is referred to as realized assets. Due to the time period involved, a complete statement of realized assets is frequently not available until the closing of the case, a maximum of two years subsequent to the filing of the petition.

Similarly, liabilities are scheduled by the bankrupt as an estimate of his indebtedness to others. They are probably fairly close to the total indebtedness, though there are occasionally discrepancies. Since he is endeavoring to free himself of all obligations, the debtor is very likely to record all obligations.

Approximately 51 per cent. of the retailers scheduled assets less than 20 per cent. of their liabilities and almost 48 per cent. of the total business group scheduled similarly limited proportions. Nine per cent. of the total business group scheduled assets in excess of liabilities. Three items—accounts receivable, real estate equities, and stock in trade—account for the excess of assets in approximately 77 per cent. of the cases. All these items are doubtlessly overestimated. There will be large shrinkage on the accounts receivable, and considerable depreciation when the stock is liquidated at forced sale. In addition, real estate values are usually based upon the 1924 to 1929 markets rather than upon present deflated values. Fixtures bring very small prices at forced sale.

Indicative of the proportions of cases and liability amounts represented by various business fields is the summary in Table V. The importance of the real

TABLE V
TOTAL BUSINESS LIABILITIES—INDIVIDUAL PROPRIETORS

| Business group | Number of cases | Per cent. of total cases | Amount in dollars | Mean in dollars | Per cent. of total amount |
|---|---|---|---|---|---|
| Total retail | 498 | 75.34 | 5,749,919 | 11,546 | 32.73 |
| Total wholesale | 22 | 3.33 | 378,911 | 17,223 | 2.16 |
| Total manufacturing | 46 | 6.96 | 1,920,073 | 41,741 | 10.93 |
| Agriculture | 4 | .61 | 21,540 | 5,385 | .12 |
| Miscellaneous trades and services | 53 | 8.02 | 1,055,821 | 19,921 | 6.01 |
| Real estate | 38 | 5.74 | 8,440,240 | 222,112 | 48.05 |
| Total—all business | 661 | 100.00 | 17,566,504 | 26,576 | 100.00 |

estate business in volume of obligations is apparent.

A similar picture is given in Table VI for certain retail trades. As indicated, restaurants are not included in the food group; the latter, in addition to groceries, includes meats, bakeries, delicatessens and other shops not serving meals.

TABLE VI
TOTAL BUSINESS LIABILITIES—RETAIL PROPRIETORS

| Business group | Number of cases | Per cent. of total cases | Amount in dollars | Mean in dollars | Per cent. of total amount |
|---|---|---|---|---|---|
| Groceries | 42 | 8.43 | 558,489 | 13,297 | 9.71 |
| Total food | 91 | 18.27 | 883,180 | 9,705 | 15.36 |
| Restaurants | 32 | 6.43 | 495,493 | 15,484 | 8.62 |
| Drugs | 28 | 5.62 | 439,527 | 15,697 | 7.64 |
| Total men's clothing | 35 | 7.03 | 272,102 | 7,774 | 4.73 |
| Total women's clothing | 72 | 14.46 | 753,253 | 10,462 | 13.10 |
| Total clothing | 134 | 26.91 | 1,362,814 | 10,170 | 23.70 |
| Total retail | 498 | 100.00 | 5,749,919 | 11,546 | 100.00 |

Of $2,388,101 owed by retailers to wholesalers, 31 per cent. was the proportion of the total obligation owed by clothing firms. Food concerns accounted for 11 per cent. Clothing outlets represented 28 per cent. of the number indebted to wholesalers, and food merchants, 18 per cent. Restaurants and drug stores were relatively most obligated to landlords.

A total of $9,693,668 of the liability was supported by collateral; two thirds of the total amount was recorded for the real estate field. Of the $1,444,266 secured liabilities in the retail trade, 23 per cent. is recorded for the food industry, 19 per cent. for clothing.

Comparisons of scheduled assets and liabilities for personal bankrupts leave small hope of settlement of creditor claims. About 70 per cent. of the cases had less than one fifth of their liabilities covered by assets. Of 15 estimating assets in excess of liabilities, 11 scheduled real estate equities.

In Table VII liabilities of personal bankrupts are recorded by occupational classifications. The special group of 80 personal bankrupts with previous business indebtedness has been excluded from this table. Individual persons and retailers were the two leading creditor groups.

TABLE VII
TOTAL LIABILITIES OF PERSONAL BANKRUPTS BY OCCUPATION

| Occupation | Number of cases | Per cent. of total cases | Amount in dollars | Per cent. of total amount | Mean in dollars |
|---|---|---|---|---|---|
| Public service | 1 | .30 | 111,911 | 2.41 | 111,911 |
| Recreation | 2 | .59 | 9,076 | .20 | 4,538 |
| Professional | 17 | 5.01 | 327,619 | 7.04 | 19,271 |
| Domestic | 20 | 5.90 | 738,773 | 15.88 | 36,938 |
| Salespersons | 65 | 19.17 | 884,832 | 19.02 | 13,612 |
| Demonstrator | 1 | .30 | 1,401 | .03 | 1,401 |
| Sales agent | 1 | .30 | 10,962 | .24 | 10,962 |
| Clerk | 41 | 12.09 | 158,827 | 3.41 | 3,873 |
| Manager | 22 | 6.49 | 711,015 | 15.29 | 32,318 |
| Laborer | 148 | 43.66 | 1,364,412 | 29.34 | 9,219 |
| Other | 21 | 6.19 | 332,267 | 7.14 | 15,822 |
| Total | 339 | 100.00 | 4,651,095 | 100.00 | 13,720 |

The proportion of scheduled assets realized at forced sale was computed for the 115 business bankruptcy cases closed by the date of this analysis. The remaining cases were still before the court for completion. The tremendous shrinkage in value between the original estimate and the receipt from sale is apparent from the fact that less than 15 per cent. of value was realized from assets of 47 per cent. of the individual proprietors and 34 per cent. of the corporations and partnerships. Eighty per cent. of the cases ultimately showed a loss to general creditors of 90 per cent. or more.

### REHABILITATION

With businesses liquidated, their assets confiscated and with neither homes nor credit, bankrupts usually leave the neighborhood of their previous activities and residence. If employed, there is some possibility of the family remaining intact. Frequently the family is divided, the wife and children going to relatives and the husband remaining in the community, attempting to locate employment. Of letters sent to the home addresses of all bankrupts three to seven months after petitioning, approximately 10 per cent. were answered, and about 55 per cent. of the letters were returned with addresses changed and unknown.

Of 42 personal bankrupts for whom this information was available, 30 had found employment. Twenty-nine of the 97 business proprietors were still unemployed. Only 22 of the former business men and 15 of the personal bankrupts were employed full time. Of those employed, the largest group obtained jobs through application from place to place, or through recommendations of friends.

One half of the business group with earned income reported income less than 60 per cent. of their respective pre-bankruptcy earnings. One half of the personal group received less than 90 per cent. of previous earnings. Ten of the former business proprietors and nine of the personal bankrupts reported earned incomes equal to or in excess of previous earnings. However, the apparent favorableness of present income is largely a relative matter. Of those recorded as receiving currently 180 per cent. or more of previous income, the range of incomes was from $200 to $1,250, indicating the very inadequate earnings of their earlier status.

Outside aid came principally from

relatives, approximately 63 per cent. of the cases receiving outside assistance recording this source. About 18 per cent. of the families were assisted by relief organizations and 10 per cent. by friends. The remaining 8 per cent. of the cases recorded miscellaneous sources.

### Proposals

It is important to recognize failures not as depression phenomena, primarily an emergency or a cyclical event, but as a continuing fundamental problem of our economic structure.

An agency is needed to propose standards and tests of ability and experience requisite to control of business enterprises in various fields. The various trade associations might logically initiate such a movement, if only in defense of their creditor members. However, the total problem transcends the interests and abilities of any trade group. It is a task for a group varying in technical and specialized knowledge.

There is urgent need for the development of cooperative management counselling by business fields, a device by which small merchants would employ in association an expert in business control with power to budget and to alter policies and processes.

Significant studies are needed to provide standards for (a) selection of store locations, and (b) establishing of the most efficient sizes of particular business units.

Creditors, in their blind desire for increase in volume of business, have oversold merchant debtors, bringing insolvency upon those they sought as customers. Both the action of trade associations and the adequate use of more efficient credit agencies is desirable.

Stimulation of consumption by pressure selling has helped to disorganize orderly purchasing. There is fundamental need of recognition that most of our population receives very low income and that purchase by the consumer of current luxuries can be accomplished only by a shift in expenditures for necessities or by deferment indefinitely of payment. Either outlet is detrimental to individual and social welfare. Careful analysis of consumer "needs" rather than potential competitive sales is overdue.

Much education is required in budgeting of business and family expenditures.

Importance of illness as a factor in failure suggests the immediate extension of social preventive and curative medicine.

Disorganization of families and of communities requires a change of emphasis from amelioration of emergency conditions to planned prevention and rehabilitation. This is a function of social organization.

# SCIENCE SERVICE RADIO TALKS

## PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

# MINERAL RESOURCES, AN INTERNATIONAL RESPONSIBILITY

By Professor RICHARD M. FIELD

DEPARTMENT OF GEOLOGY, PRINCETON UNIVERSITY

HUMAN beings are absolutely dependent upon their environment, but their environment has become so complex that they are likely to forget the fundamental physical and biological factors which are still essential to existence. Man's social evolution has taken at least two hundred thousand years, and during most of this time his primary concern has been the same as that of all other animals—the need of food, a suitable physical environment and the desire to have children. While even to-day these still remain the primary wants of human beings, during the last few thousand years man, through the accumulated experience of his ancestors, has developed and expanded the possibility of his environment until it has become the infinitely complex sum of those so-called necessities for his health and his happiness which he considers to be an important part of modern civilization. To-day the lives of millions of men and women do not depend so much upon their individual efforts in acquiring the raw products from the breast of mother nature, as upon a common social scheme by which the raw natural resources of the earth are refined and made useful to all. In this modern age of invention, mass production and faulty methods of distribution, we are apt to forget that the physical character of modern civilization is controlled by the diversity, the quality, the quantity, and the geographic distribution of raw natural resources.

All natural resources may be grouped under two principal divisions, agricultural and mineral. Mineral resources have become increasingly important during the social evolution of man, culminating in what is often referred to as the machine age. Obviously, there would be no modern machines or the products of these machines, if there were no metals. It is a peculiar attribute of all metals that they are extracted from minerals. The economically important minerals have been concentrated by nature in the form of ores. When these ores have been exhausted they can not be reproduced by man. Minerals, unlike the essential elements of food and clothing, can not be reproduced as can raw agricultural products. The mineral fuels of the world also constitute an energy reserve which has been similarly created by natural agencies through millions of years, and which man may consume but he can not reproduce. The ultimate supply of mineral resources naturally depends upon the discovery of new supplies and the rate of consumption. Unquestionably man has not discovered all the mineral resources, including coal and oil. The recently improved methods of prospecting and refining have added greatly to the world's reserve of metals and fuels. Man is, therefore, concerned with the quality and amount of mineral reserves, but the problem of conservation is not as prominent as it was a few years ago. At the present time the geographic dis-

tribution of coal, oil and rich concentrates of metallic minerals is far more important, from an international point of view.

Exclusive of the precious metals, platinum, gold and silver, there are twelve important metals which occur in the complex form of minerals. According to statistics accumulated by the United States Government "28 minerals constitute more than 70 per cent. of the gross value of the mineral raw materials of commerce." At the present time two thirds of the essential mineral resources of the world are controlled by the United States and the British Empire, that is, by the English-speaking peoples. In other words, the English-speaking peoples have, by one means or another, gradually acquired the absolute, or partial, control of the major proportion of by mineral wealth. This mineral wealth the earth's surface which is underlain supplies twelve important metals, which are first, the base metals, iron, copper, aluminum, lead, zinc, tin and nickel; and the alloy metals, or hardeners, antimony, chromium, manganese and tungsten.

Besides the above-mentioned metals, there are the important non-metallic minerals, such as coal, oil, nitrates, phosphates, potash, and a number of others essential to industrial and agricultural prosperity.

In normal business times the United States has all the minerals which she needs within her own sovereign territory, with the exception of the alloy metals and nitrates.[1] It is perhaps news to some that, in spite of the fact that the United States produces nearly 71 per cent. of the world's petroleum, in good business times she consumes over this amount.[2] The only net excess of raw mineral commodities which the United States has for export are coal, phosphates and sulfur. Although the United States is exceedingly rich in mineral resources, she consumes more than any other nation by reason of the number and energy of her people, whose wealth depends upon foreign, as well as domestic, trade.

Since the world war, Germany has an inadequate supply of metallic minerals to meet her domestic demands. She has a very limited supply of copper, iron and lead ores within her sovereign territory, and is entirely dependent upon other countries for all the other metals. Germany does, however, have more coal and potash than she needs for her own consumption.

France, at the present time, is in reality only a little better off than Germany. She has more aluminum potash and iron than she needs, but, like Germany, she now imports her petroleum. France also, normally, imports part of her coal.

England has an excess of coal and an adequate supply of iron, some lead and tin, but has to import everything else. If, however, we consider England as the center of the British Empire, then the

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[1] The United States produces over a million and a quarter tons of synthetic sodium nitrate a year. The total United States nitrogen production is well over 600,000 tons, which is far in excess of either our peace or war-time requirements (Professor J. Enrique Zanetti, Department of Chemistry, Columbia University). This is an illustration of how the former necessity for Chile saltpeter is being overcome by inventive ingenuity and leads to the statement "It should be abundantly evident that public affairs are being more and more divorced from the classical rules of international diplomacy, and are becoming increasingly susceptible to conditions imposed not only by accident of material distribution but also by excellence of scientific and technical achievement" (Professor Hugh S. Taylor, Department of Chemistry, Princeton University). It is hardly to be expected, however, that even eventually the ingenuity of the chemist will entirely overcome the economic problems arising from the unequal geographic distribution of *mineral* resources (R. M. Field).

[2] While several countries have succeeded in substituting powdered coal and petroleum distilled from bituminous shale and coal, none of these products can be produced as cheaply as natural petroleum (R. M. Field).

picture is quite different, for the British Empire has an excess of all the essential minerals, with the exception of antimony, potash and mercury.

The economic power of Great Britain, therefore, really depends entirely upon the solidity of the British Empire, and her ability to derive industrial minerals from sources which she either politically or commercially controls. Thus, while she surpasses the United States in the control of excess mineral resources, this control is not exercised within her sovereign territory, but is exceedingly far-flung and is held only with increasing difficulty.

The Japanese situation is the present outstanding problem in mineral resources. Japan has barely enough copper and zinc for domestic consumption. She has an inadequate supply of iron, chromite, manganese, coal and petroleum, and is *entirely* dependent on other nations for all other mineral supplies. Hence Japan is tremendously interested in assuring herself of the continuing right to exploit the mineral resources of neighboring territory, because she will thus become much more independent of foreign nations than she is at the present time.

Belgium has no adequate supply of minerals for her needs, except coal and copper, and has to import all important minerals.

Italy is probably in at least as difficult a position as Japan, as she has no control over petroleum and coal, and is but little better off as to iron and lead. It should be noted that both Italy and Japan now rank as first-class powers, and are struggling to maintain that position in spite of serious deficiencies in their mineral resources. They are in an even worse position than England would be if she were divorced from the British Empire.

Spain presents an entirely different problem since, with the exception of certain ferro-alloys, coking coal and perhaps petroleum, she has deposits of most of the important mineral resources within her sovereign territory, and has an excess of copper, iron, lead, manganese and mercury for export. Here we have a clear case of a nation that is playing a passive rôle in the development of her natural resources, and, therefore, may eventually become a source of trouble to herself and a cause of discord in the international affairs of Western Europe. "The political boundaries of the nations, originally drawn on considerations dominantly agricultural in origin, have now no natural relation to the national reserves of mineral wealth."[3] This is a very serious situation, which has exerted and will continue to exert a powerful effect on commerce and world peace. The developments of peace have moreover fundamentally changed military requirements for war. Because of the improvement and complexity of machinery used in war, mineral resources are now a vital factor in both attack and defense. The fact that the Allies did sell essential minerals to Germany for the manufacture of lethal weapons will serve to illustrate still another difficulty which arises from the unequal geographic distribution of mineral resources. Tungsten is an essential element in the manufacture of high-grade tool steel. The principal source of tungsten is the mineral w-o-l-f-r-a-m-i-t-e, obtained mainly from South Burma. The Burma mines are controlled by the British. When the world war broke out, the Germans had laid in two years' supply of wolframite. When Germany had used up her imported reserve of wolframite she procured m-o-l-y-b-d-e-n-u-m as a substitute for tungsten from a neutral nation, Norway. This move was partly countered by the British purchase of this Norwegian output. Germany then substituted the next best alloy metal, nickel, in quantities ten times greater than Central Europe

[3] Sir Thomas Holland.

could produce; so she imported her nickel through the neutral Scandinavian countries, and they, being neutral, were able to obtain nickel from Canada—the world's main source of rich nickel ores. In prohibiting the use of tungsten in Germany, England dealt her a serious blow; had England, however, been able to keep Germany from acquiring an adequate supply of nickel, the Allies would undoubtedly have won an earlier victory.[3]

The conclusion to be drawn from the above digest is that the mineral resources of the world are too few and irregularly distributed for each nation to become self-sufficient. Some nations have more than their share of the great mineral reserves; some lack adequate reserves; and even the particularly blessed lack some important minerals. This has been known by geologists for many years.

No matter what other factors may affect international affairs, there never can be established a reasonable degree of friendship among nations, with the consequent reestablishment of world prosperity, until the geographic distribution of mineral resources is seriously considered from an international point of view.

# EARTHQUAKES—WHAT ARE THEY?

**By the Reverend JAMES B. MACELWANE, S.J.**

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ROUND about this earth of ours there run certain belts in which earthquakes occur more often than in other parts of the world. Why should this be the case? We read from time to time of destructive earthquakes in Japan. But many lesser shocks occur there of which we never hear. In fact, there is an earthquake, large or small, somewhere in Japan practically every day. Similarly, the Kurile Islands, the Aleutian Islands, Alaska and the Queen Charlotte Islands are subject to frequent earth shocks. Continuing around the Pacific circle, we meet with many earthquakes in California, Mexico, Central America, Venezuela, Colombia, Equador, Bolivia, Peru and Chili. And on the other side of the Pacific Ocean, the earthquake belt continues from Japan southward through Formosa and the Philippine Deep to New Zealand. Another somewhat less striking earthquake zone runs from Mexico and the Antilles through the northern Mediterranean countries and Asia Minor into the Pamirs, Turkestan, Assam and the Indian Ocean. In other parts of the earth, destructive earthquakes also occur, but as more or less isolated phenomena. Examples in this country are the Mississippi Valley earthquakes of 1811 and of the following year, and the Charleston earthquake of 1886.

Now why should destructive earthquakes occur more frequently in such a zone or belt as is the border of the Pacific Ocean? What is an earthquake? Centuries ago, many people, and even scientific men, thought that earthquakes were caused by explosions down in the earth; and there have not been wanting men in our own time who held this view. Others, like Alexander von Humboldt, thought that earthquakes were connected with volcanoes; that the earth is a ball of molten lava covered by a thin shell of rock and that the volcanoes were a sort of safety valve. As long as the volcanoes are active, they said, the pressure within the molten lava of the earth is held down, but when the volcanoes cease their activity, thus closing the safety valves, so to speak, the increasing

pressure eventually causes a fracture in the earth's crust. Another theory supposed that the lava occupied passageways in a more or less solid portion of the earth underneath the crust and that the movement of lava within these passages caused such pressure as to burst their walls, thus causing an earthquake.

Quite a different point of view was taken by those who held the theory that earthquakes occurred within the uppermost crust of the earth. This crust was supposed to be honeycombed with vast caves. Even the whole mountain chain of the Alps was thought to be an immense arch built up over a cavern. When the arch would break, thus allowing the overlying rocks to drop somewhat, we would have an earthquake. In many cases, those who held this theory believed that the entire roof would collapse and that earthquakes are generally due to the impact of the falling mass of rocks on the floor of the cavern.

But it has been shown, since the discovery of the passage of earthquake waves through the earth and their registration by means of seismographs, that the outer portion of the earth down to a depth of at least five elevenths of the earth's radius is not only solid, but, with the exception of the outer layers, is more than twice as rigid as steel in the laboratory. It has also been shown that volcanoes are a purely surface phenomenon; that they have no connection with each other, even when they are but a few miles apart. Hence it is clear that earthquakes connected with volcanoes must be of very local character, if they are to be caused by the movement of lava. This is found to be actually the case. It is also clear that some other cause must operate in producing earthquakes, since destructive earthquakes often occur very far from volcanoes. In fact, some regions where there are frequent earthquakes have no volcanoes at all.

In the California earthquake of 1906, there occurred a fracture of the earth's crust which could be followed at the surface for a distance of more than 150 miles, extending from the Gualala River Valley on the northern coast of California southeastward through Tomales Bay and outside the Golden Gate to the old mission of San Juan Bautista. The rocks on the east side of this fracture moved southeastward relatively to those on the west side, so that every road, fence or other structure which had been built across the line of fracture was offset by varying amounts up to 21 feet. A study of this earthquake led scientific men to the conclusion that the mechanism of the earthquake was an elastic rebound. It was thought that the rocks in the portion of the earth's crust west of the fracture had been dragged northward until the ultimate strength of the rocks was reached along this zone of weakness. When the fracture occurred, the rocks, like bent springs, sprang back to an unstrained position. But this did not occur in one continuous throw, but in a series of jerks, each of which set up elastic vibrations in the rocks. These vibrations traveled out in all directions and constituted the earthquake proper. The zone of weakness in which the California earthquake occurred is a valley known as the San Andreas rift. It is usually quite straight and ignores entirely the physiography of the region, passing indifferently over lowlands and mountains and extending more than 300 miles beyond the end of the fracture of 1906 until it is lost in the Colorado desert east of San Bernardino. The entire floor of the valley has been broken up by earthquakes occurring through the ages into small blocks and ridges and even into rock flour.

The San Andreas rift is only one of the many features which parallel the Pacific Coast in California. There are other lesser rifts on which earthquakes have occurred. Similar to these rifts in some respects are the ocean deeps, along

the walls of which occur some of the world's most violent earthquakes.

Why do these features parallel the Pacific shore? And why are earthquakes associated with them? Both seem to be connected in some way with the process of mountain-building, for many of the features in this circum-Pacific belt are geologically recent. Many have thought that mountain-building in general and the processes going on around the Pacific in particular are due to a shortening of the earth's crust caused by gradual cooling of the interior and the consequent shrinkage, but this is not evident. While the earth is surely losing heat by radiation into space, it is being heated by physical and chemical processes connected with radioactivity at such a rate that, unless the radioactive minerals are confined to the uppermost ten miles or so of the earth's crust, the earth must be getting hotter instead of cooler, because the amount of heat generated must exceed that which is conducted to the surface and radiated away.

Another suggested cause of earthquakes is isostatic compensation. If we take a column of rock extending downward from the top of a mountain chain to a given level within the earth's crust and compare it with another column extending to the same level under a plain, the mountain column will be considerably longer than the other and consequently will contain more rock. Hence it should weigh more, unless the rocks of which it is composed are lighter than those under the plain, but geodesists tell us that the two columns weigh the same. Hence the rocks under the plain must be the heavier of the two. But even if this is the case, we should expect the conditions to change; for rain and weather are continually removing rocks from the tops of the mountains and distributing the materials of which they are composed over the plain. Nevertheless, according to the geodesists, the columns continue to weigh the same. Hence we must conclude that compensation in some form must be taking place. There must be an inflow of rock into the mountain column and an outflow from the plain column. But the cold flow of a portion of a mass of rock must place enormous strain on the surrounding portions. When the stress reaches the ultimate strength of the rocks, there must be fracture and a relief of strain, thus causing an earthquake.

It has recently been found that earthquakes occur at considerable depth in the earth. Hence they can not be caused by purely surface strains. There are a few earthquakes which seem to have occurred at depths up to 300 miles. This is far below the depth of compensation of the geodesists. It is also below the zone of fracture of the geologists, and far down in what they call the zone of flow. Can an earthquake be generated by a simple regional flow? We do not know, but it would seem that sudden release of strain is necessary to cause the vibrations which we call an earthquake. It may be that a strain is produced and gradually grows in such a way as to produce planes of shear such as occur when a column is compressed lengthwise. These planes of maximum shear usually form an angle of about forty-five degrees with the direction of the force. Recent investigation into the failure of steel indicates that under certain conditions it will retain its full strength up to the moment of failure when the steel becomes as plastic as mud along the planes of maximum shear. The two portions of the column then glide over each other on the plastic zone until the strain is relieved, whereupon the steel within the zone becomes hard and rigid as before. It may be that a process somewhat similar to this may take place deep down in the earth, and that the sheared surface may be propagated upwards through the zone of flow

to the zone of fracture and even to the surface of the earth. In that case, the plastic shear would give way to true fracture near the surface.

It is only by a careful study, not only of the waves produced by earthquakes and of the permanent displacements which occur in them, but of the actual movement along the planes of fracture, that we shall be able to discover what an earthquake really is. For the present, we must be satisfied with knowing that it is an elastic process; that it is usually destructive only within a very restricted belt, and that it is probably produced by the sudden release of a regional strain within the crust of the earth.

# HEALTH EXAMINATIONS AND CANCER

By Dr. FRANKLIN H. MARTIN

DIRECTOR-GENERAL, AMERICAN COLLEGE OF SURGEONS; CHAIRMAN, BOARD OF DIRECTORS, GORGAS MEMORIAL INSTITUTE

Comeliness of personal appearance is inconsistent with ill health. All men can not be handsome and all women can not be beautiful, but every man and every woman can have an interesting personality and a comely body and become an efficient citizen. However, such a wholesome picture can not be maintained with a defective body.

There is no economy in sickness. If every organ of our bodies were as conspicuous as our teeth, the defects of which are apparent to all every time we open our mouths, many sensitive people who are now harboring disease would seek comeliness and not advertise the evidence of unfitness.

Since I was born—and perhaps also since many of my listeners were born—the practise of medicine has been transformed from a mere art to an exact science. With our modern diagnostic facilities, the educated doctor of medicine can make an accurate diagnosis. An examination conducted by such a doctor will reveal your bodily ills; it will reveal diseases in their earliest stages when they are amenable to cure.

The American College of Surgeons—which consists of 10,733 leading surgeons and surgical specialists—has organized a program of prevention of disease. Sectional meetings of the College are held periodically in various parts of the United States and Canada. One phase of these meetings is a community health session, at which a group of skilled physicians, surgeons and scientific specialists make short, heart-to-heart talks to the people and advise them how to keep well. They tell the people about the prevention and cure of disease, in other words, all the things that doctors, as partners of the people, are qualified to discuss interestingly and understandingly.

*First,* our speakers tell you that in 1916 the great hospitals of the country were taken into partnership by the College and that we have expended a total of one million dollars to achieve the goal of proper hospital care of the sick and injured. Hospitals, to secure approval, must meet a standard that has been fixed by the College. This standard insists, as a minimum, that membership upon the staff shall be restricted to physicians and surgeons who are graduates of medicine in good standing and legally licensed to practise scientific medicine, who are competent in their respective fields and worthy in character and matters of professional ethics (and under no circumstances irregulars); that the staff shall meet once a month to audit the medical and surgical work conducted in the hospital during the preceding interval; that

accurate and complete case histories shall be written and filed so that a record of the procedures of each member of the staff may be available at all times; that modern scientific apparatus shall be provided, and that an approved clinical and pathological laboratory shall be maintained to insure facilities for correct diagnosis.

The College does not obtain its information about hospitals through correspondence, or local or general committees. Actual surveys are made by salaried employees of the College—graduates of Class A medical schools, men of maturity with an extensive training in clinical work and hospital administration. These representatives send disinterested reports of their findings to the central headquarters, where all data are reviewed and the hospital rated.

One in every ten of the people who are within sound of my voice will require hospital care within the next twelve months. Will you seek one of the hospitals approved by the American College of Surgeons, or will you select one of the three thousand hospitals that have not met these reasonable requirements?

*Second,* our speakers present convincing proof of the benefits that will accrue to you and to your families if each of you will insist upon an annual or semiannual health audit by your own family doctor, a careful and scientific inspection of every organ and every part of your body—that most intricate machine—in order to discover any defects in its mechanism.

*Third,* they tell you something of the diseases that are preventable, and they give you information that will enable you to recognize such diseases if they should reveal themselves between your regular inspections so that you may seek immediate relief. Oftentimes, if diseases are discovered early enough, precautionary measures may be advised and medical or surgical treatment may be obviated.

*Fourth,* they warn you that subtly developing maladies—heart disease, kidney diseases, diabetes, high blood pressure, stomach ulcers, diseases of the female pelvic organs and malignant diseases—may be promptly arrested and cured if they are diagnosed in their earliest stages.

*Fifth,* they give you information in regard to nutritional irregularities which cause obesity, leanness, skin blemishes, sallowness and other uncomely manifestations.

*Sixth,* they tell you that cancer is curable, and illustrate the fact by presenting records of many thousands of cures. They tell you of the apparent signs of cancer, and enlarge upon important details of cure. They tell you of the various stages of cancer so that you may seek scientific advice and forestall its development before it reaches the stage of incurability; they advise you to seek proper treatment of cancer, in whatever stage of development, that you may not, through ignorance of symptoms, fail to take advantage of scientific advice during the curable stage, and also that you may secure palliative treatment that oftentimes prolongs life and secures freedom from painful symptoms.

Many within the hearing of my voice may not be familiar with the early signs of cancer. They are as follows. Listen and remember.

A neglected skin blemish or persistent soreness may become a skin cancer. A small lump in the breast is a danger signal, and the family physician should be consulted at once. The lump may be the forerunner of an incurable breast cancer. Persistent indigestion or stomach distress are among the early symptoms of cancer of the stomach, and cure may be effected and progress arrested by immediate attention. Unnatural, irregular hemorrhages from any portion of the body should lead one to consult the family doctor immediately. There are other signs, but these are the outstanding ones.

Men and women, why not be on the safe side? Why wait for danger signals? Go to the human engineer, your own family physician, once in six months and have the human machine thoroughly inspected. Then you will be safe from all diseases. If you should be developing a cancer, it will be discovered in its very earliest stage—when it can be cured.

At a recent meeting of the American College of Surgeons, an innovation of outstanding importance was initiated. As a part of the scientific meetings of the college, thirty of the leading specialists of medicine and surgery reported actual cures in 4,348 cases of cancer—patients who were treated from five to twenty years ago and who were definitely cured of cancer.

In addition to the cures reported at this meeting by this limited group of specialists, the American College of Surgeons, through its committee on the treatment of malignant diseases, presented records of 1,263 additional cases of cures of five years or more which have been added to the archives of cures of malignant diseases.

The College, through its Department of Literary Research, also obtained from the literature reliable recent reports of 3,089 additional cures of cancer. The grand total of cancer cures which were reported by the College on October 20 was 8,840, and our survey was by no means an exhaustive one. This means a saving of approximately sixty thousand years. This innovation in the study of cancer was inaugurated by the college to impress upon every one the fact that cancer is curable by the use of the well-known and established methods of treatment that are approved by the profession of scientific medicine.

May I emphasize the fact that if every case of cancer could be diagnosed early and treated properly in its incipiency, the present annual death rate from cancer, now recorded as 150,000 in the United States and Canada, would be reduced by at least 33 per cent. or 50,000 per year. This early diagnosis and early treatment, may I again emphasize, can be insured only if the individual takes the precaution of submitting himself to an annual, or better, a semi-annual health audit, conducted by his own scientific family doctor.

Other beneficial results will accrue from this dissemination of proof of the curability of cancer. The scientific medical profession will be spurred on to ever greater efforts in its research into the cause of cancer, and in advocating early diagnosis; the discouraging psychosis that now exists in the minds of the public will be dispelled; a consciousness that cancer is curable will be established in the minds of all; fear will be displaced by a spirit of hopefulness; and every victim of cancer or suspected cancer will present himself for early diagnosis so that any and all diseases may be discovered in their incipiency, when they are amenable to treatment and cure.

Remember that a great disinterested body, the American College of Surgeons, has announced authentic cures of cancer as follows:

| | |
|---|---|
| Pelvic organs | 1,948 |
| Breast | 3,634 |
| Bladder, kidney, and other genito-urinary organs | 439 |
| Colon and rectum | 116 |
| Thyroid | 165 |
| Larynx | 50 |
| Mouth | 867 |
| Stomach | 356 |
| Skin | 866 |
| Bone | 90 |
| Other classifications | 309 |
| Grand total of cancer cures five years and more | 8,840 |

Remember also the slogan—"Cancer is curable"; and remember, too, to present yourself to your scientific family doctor for an annual or semi-annual health audit.

# SCIENCE AND GOVERNMENT

By Dr. HUGH S. TAYLOR

DAVID B. JONES PROFESSOR OF CHEMISTRY, PRINCETON UNIVERSITY

NATURAL resources, especially the mineral resources of the world, are an international responsibility, as has once more been emphasized in a recent radio address[1] by Professor R. M. Field, of the Geology Department in Princeton. Irregularity in the distribution of such resources throughout the nations of the world is a factor of manifest importance in the problem of international friendships and hatreds. The problems that arise thereby are obviously such as to demand cooperation not only of statesmen, diplomatists and economists, but also of scientists—a new technique in international affairs.

The difficulties attendant upon the solution of such problems are intensified because progress in scientific achievement may profoundly modify the extent of power accruing from the possession of a raw material. An excellent example of this is to be found in Chile saltpeter. This naturally occurring source of nitrates, required alike for peace-time agriculture and war-time explosive, was, prior to 1914, almost exclusively the monopoly of the republic of Chile. Chile saltpeter was carried in sea-borne consignments to the civilized countries of the world. This sea-traffic was an important consideration leading to the construction of the Panama Canal, with its accompanying international problems. The export tax upon the saltpeter was adequate revenue for the conduct of all state business in Chile. Her battleships were the most modern among the fleets of the South American Republics. To-day all the great nations of the world are drawing supplies of fixed nitrogen from the air. Chile's contribution to nitrogen production and consumption was but 23 per cent. in 1929, as contrasted with 50 per cent. in 1913. The direct synthetic ammonia process, an industrial development from fundamental principles of chemical equilibrium, initiated by Professor F. Haber, of the Kaiser Wilhelm Institut in Berlin, was brought to technical development in Germany in 1913. The year is worthy of note. In 1929, as much as 44 per cent. of the nitrogen production and consumption was from the synthetic ammonia process. Chile is suffering from governmental troubles with increased internal taxation necessary. The curtailment of saltpeter exports is a factor, also, in depressed shipbuilding and ship-operating nations, indirectly affects export trade of many nations and is thus a familiar example of general depression conditions in the world to-day. The point to be emphasized is, however, that this condition arises not from an accident of monopoly in world resources but from the interplay of scientific progress with economic and indirectly with political and social conditions.

All monopolies of raw materials may be exposed to similar threats from technical progress. During the Great War, Germany devised ways and means to be independent of the control of the world sulphur market by the United States. New methods of deriving sulphuric acid from materials available at home were evolved. Germany and Great Britain are striving at the present time to derive synthetic oil fuels from coal, to offset the advantages accruing to the

[1] Included in the present number.

United States from her production of 71 per cent. of the world's petroleum; alternatively the use of powdered coal as a substitute for oil fuel is being intensively studied. In the opposite camp, the development of synthetic rubbers, such as "Duprene" by E. I. du Pont de Nemours and Company or "Thiokol" by the Thiokol Corporation, is evidence of an intent to mitigate the rigors of Dutch and English rubber control. From an earlier period, the successful syntheses of indigo and of camphor in the laboratories of Germany may be cited as of decisive significance in the former monopolies of India and of Japan respectively in these commodities. The tremendous recent developments of synthetic textiles, such as rayon, is a further factor in the economic condition of the Japanese nation, of concern to its silk industry, which may be of significance in the recent international activities of Japan.

It should be abundantly evident, therefore, that public affairs and international relations are being more and more divorced from the classical rules of international diplomacy and are becoming increasingly susceptible to conditions imposed not only by accident of materials distribution but also by excellence of scientific and technical achievement. Chemistry appears to be in international policies to stay. Atomic disintegration and the harnessing of atomic energy, when they arrive, will still further harass the economist and statesman. It, therefore, behooves those responsible for the training of future generations in government to take cognizance of this definite trend in human affairs. With a few conspicuous exceptions, the wide spaces of the earth are explored and claimed. The age of discovery is giving place to the age of exploitation. Science is at once the most potent and unpredictable weapon for such exploitation. Students of public affairs and international relations must, of necessity, become increasingly understanding in the scientific point of view. It is with some such thoughts in mind that the undergraduate of to-day should approach his subjects of study if he be minded to embark upon a life of public or international service. Let him in this wise examine the curricula which are suggested for his training in such fields of effort. They may suggest to him the desirability that before he pass out from the undergraduate years to the larger opportunities of life outside he would do well to accumulate at least the fundamentals of those scientific subjects which all too definitely are of importance in problems of human affairs and all too obviously are neglected in the present organization of educational efforts to this end. It is essential that, in the problems of government in the future, due attention shall be paid to "Science comforting man's animal poverty and leisuring his toil" . . . "working back to the atoms, she handleth their action to harness the gigantic forces of eternal motion, in serviceable obedience to man's mortal needs."

# THE FUNDAMENTAL UNITS OF THE PHYSICAL WORLD

By Dr. RUDOLF W. LADENBURG

BRACKETT RESEARCH PROFESSOR OF PHYSICS, PRINCETON UNIVERSITY[1]

MODERN physics studies the properties and the structure of the atoms and molecules; for the atoms which form the molecules and build up every substance are not indivisible, in spite of their name. What are their building stones? Up to last year we thought that they were the units of positive and negative electricity and that these were quite different in mass and in size; that the smallest amount of positive electricity, the so-called proton, was always connected with the mass of a hydrogen atom and that the unit of negative electricity, the electron, had a mass 1,800 times smaller than that of a proton.

These are the two fundamental units of the atom, formed according to the famous ideas of Rutherford and Bohr; nearly the whole mass being positively charged, the "nucleus," in the center, surrounded by moving electrons which rotate around the nucleus like the planets around the sun.

There is a wealth of spectroscopical and chemical facts arranged on the basis of this picture. Perhaps the most beautiful result is the long-sought explanation of the periodic table, where the 92 chemical elements are ordered according to their atomic mass. The number which each element carries in this table—hydrogen (1), helium (2), lithium (3) and so on, up to uranium, number 92—is the number of positive charge units carried by the nucleus and at the same time the number of negative electrons which surround each nucleus. And the similar properties of the elements which belong to the same vertical group—the alkali metals lithium (3), sodium (11), potassium (19), etc., or the rare gases helium (2), neon (10), argon (18) . . . are to be understood by the similar arrangement of the electrons in the outside shells or groups.

Now, the picture of these rotating electrons is not correct—it has been changed and improved to a large extent by the much-beloved quantum and wave mechanics, and yet the Rutherford-Bohr idea does not lose its importance. The importance of an idea does not lie, as Planck said in a recent lecture, in the amount of truth—it lies in the amount of fruitful work which the idea generates, and the fruitful work generated by Rutherford-Bohr's ideas is enormous. The views of that which is true change; the experimental facts remain.

The problem of modern physics is no longer the constitution of the whole atom; we have no doubt that the picture of the nucleus, which contains the greater part of the mass, the positive charge surrounded by the negative electrons, and the quantum-mechanical description of the action between these particles, is capable of explaining most of the chemical and physical facts. The most urgent question in physics is now: What is the structure of the nucleus? What are its fundamental units?

There is no doubt that the different nuclei of the 92 elements are not 92 different units, they all contain as many protons of mass 1 as the atomic weight indicates. If the atomic weight is not a whole number, that is, not a whole mul-

[1] Formerly in the Kaiser Wilhelm Institut für physikalische Chemie und Elektro-Chemie in Berlin-Dahlem.

tiple of the hydrogen mass which is taken as unity, it is because the elements are mixtures of different species. These are the "isotopes," so called because they occupy the same place in the periodic table, and the mass of each atomic species is very nearly a whole number. Thus the old idea of Proust is confirmed by modern atomic physics. The radioactivity of the heaviest elements—uranium (92), protactinium (91), thorium (90), actinium (89) and radium (88) —teaches us more about the nucleus. For these elements disintegrate spontaneously—they go over into other elements, either of lower atomic number and mass while emitting very fast alpha-particles that are nuclei with mass 4 of the element number 2 called helium, or they go over in an element of the same mass but of larger atomic number while sending out a so-called beta particle that is a negative electron, the other brick of the atom.

These facts have been known for a long time. But it is also possible to disintegrate some nuclei artificially. By bombarding light elements, as numbers 5, 7, 9, 13, with alpha particles given off from radioactive substances, Rutherford and his collaborators showed, about 14 years ago, that they are transformed into other elements. The alpha particle (the helium nucleus) usually sticks to the bombarded nucleus and this gives off a proton—a hydrogen nucleus. That is a great step forward in our knowledge of the nucleus.

The last year brought us some new and very important discoveries in this line of research: besides the proton, a new unit was found which is given off by some elements when bombarded by fast alpha particles—an uncharged particle of the mass of the hydrogen atom, the so-called neutron, which may be the element number 0 hitherto unknown, and yet expected by different theoretical considerations. Furthermore, *purely* artificial disintegration was discovered. The alpha particles which were used before as bullets for bombarding the atoms are still natural fragments of radioactive substances. An even more powerful tool for disintegration are the protons themselves, artificially generated by ionizing hydrogen gas, and accelerated by means of potentials of some 100,000 volts. In bombarding some light elements with such fast protons, one obtains alpha particles of the enormous energy of some million volts emerging from the bombarded atoms. The lithium nucleus, for example, contains 3 positive charges and seven protons. When hit by a fast proton it gives off two alpha particles of about 8 million volts. This means that the lithium nucleus catches a proton and breaks up completely, for the new-formed alpha particles are helium nuclei and contain as many protons and positive charges as the lithium and proton together. But their masses are somewhat less than the masses of the lithium and the proton. This mass difference just accounts for the gain of kinetic energy of two times 8 million volts; for according to one of the fundamental discoveries of Einstein, mass can be transformed into energy and *vice versa*. Otherwise the formation of the 8 million volt alpha particles would be a complete breakdown of the conservation of energy and we could not understand it at all. Indeed, these experiments, carried out by Cockcroft and Walton in Rutherford's laboratory in Cambridge, are perhaps the most beautiful proof of the Einstein mass-energy relation. So the energy stored up in the lithium nucleus is transformed into useful kinetic energy. As a matter of fact, the efficiency of this wonderful process is very small indeed. For the size of the nuclei is so small that we need two hundred million protons of half a million volt energy for a single hit of a lithium nu-

cleus. Therefore, only a vague hope remains that it may be possible some time from now to make this process useful for practical purposes.

On the other hand, the scientific importance of such experiments can scarcely be overestimated, and that is the reason why many scholars are engaged in high voltage work. I may mention the Van de Graaff electrostatic generator, described in this journal some months ago, which was constructed in the Palmer Physical Laboratory. Dr. Van de Graaff himself is now constructing a very large generator for about 10 million volts at the Massachusetts Institute of Technology. A modification of his machine, for use at high pressure, built by Henry A. Barton, D. W. Mueller and L. C. Van Atta, and able to produce one million volts, is still here. That same reason induced us to install in this laboratory a large transformer-kenotron outfit for producing about 500,000 volts. This has the advantage of great steadiness and of about 30 times more current than the Van de Graaff generator. The number of disintegrated atoms can therefore be increased many times, and important problems can be investigated which appear to be hopeless with a small amount of current.

On the other hand, the higher the energy of the bombarding particles, the more new and striking effects may happen. The last important and surprising discovery in physics was obtained by using the very penetrating cosmic rays, recently announced by Carl D. Anderson, Pasadena, California, and by P. M. S. Blackett and G. Occhialini, of Cambridge, England.

The question of the nature of these rays is not yet settled; it seems that they are composed partly of charged particles and partly of electromagnetic waves of x-ray type, only very much more penetrating than the hardest x-rays. There is no question that some of these particles, or say quanta, contain the very high energy of some billion volts—that is, about 1,000 times more than we are able to produce to-day. Now it is found that these quanta or particles disintegrate atoms—why should they not when protons of only 100,000 or even 15,000 volts energy do? But the very astonishing and quite fundamental discovery is that the particles which are produced or released by this process are positive electrons of light mass, christened positrons—it means positively charged particles of much smaller mass than a hydrogen atom or a proton.

Hitherto, as I pointed out at the beginning, electricity was considered to be very asymmetrical: the negative electron of very small mass as the unit of negative electricity and the proton of 1,800 times larger mass as the unit of the positive charge. Now, the positive electron appears, which seems to be a better counterpart of the negative electron than the proton, and this similarity between the positive and negative charges is more satisfactory from a philosophical standpoint than was the former picture. But the question now arises: Is the neutron a fundamental particle rather than a positive proton and a negative electron in a close combination, and is the proton perhaps a complex particle consisting of a neutron and a positron? What are the fundamental units?

# IS SCIENCE EXACT?

By FREDERICK H. LORING
LONDON, ENGLAND

Lord Birkenhead on one occasion, in giving an outside opinion, remarked that science was both exact and exacting. Those on the inside might be pleased with this statement, but amongst themselves they have to admit that, while in many fields of research very great precision obtains, there are some dense fogs hanging over certain advanced phases of the subject which darken the view and so prevent one from seeing clearly or exactly what takes place. At the same time conjectures based on many considerations are made and theories mathematically formulated. These theories are being put to the most exacting tests imaginable by those interested in their welfare, and it should be just as much a pleasure to confirm a theory as it is to furnish data which completely upset it. In this way the fabric of science is constantly being strengthened and the theories recast or new ones supplied. The late Lord Birkenhead's dictum is just as much an ideal aim as ever it was.

So much for a general statement; but what are the particular inexactitudes, if they may be so labeled, that are, or have been, exercising the minds of men of science?

## The Inexactitudes

The theory of relativity proved Newton's theory to be inexact, for the former theory showed that more experimental facts could be consistently coordinated. This theory also helped to abolish the older conception of the ether[1] and thereby produced a mental hiatus, so to speak, and the problem of supplying a suitable ether has been left unsolved, and in its place are the mathematical equations which work well in many ways; so that, for all practical purposes, no space-filling material-like medium is required for the functioning of the phenomena of light or radiation or even of gravity. Space thus becomes endowed with characteristics peculiar to differential equations, and some begin to think that the mind can not properly grasp such matters apart from the mathematical working, nor should it attempt to do so. It is not a proper question to ask or to solve, any more than in the Christian religion it is proper to ask who made God. As a matter of fact the whole trouble here is the exactness of the principles evolved by Einstein as supported by the contributions of H. A. Lorentz, Minkowski and others, speaking particularly of the special and general theories of relativity. These epoch-making theories solved so many problems at one stroke that there was left no choice about it but Hobson's. They were, moreover, all-embracing for large-scale phenomena.

The mind of man is never quite satisfied, and one may expect to see the ether reinstated some day. Just what this ether will be is not known. Sir Oliver

[1] ''The theory of relativity in effect requires that it shall be impossible to decide as to whether an ether exists or not, either by these or by any other purely mechanical considerations; the equations of radiation and absorption of energy are precisely the same whether the energy is radiated into, and absorbed from, an ether or empty space. The analysis we shall now give will show that the existence or non-existence of an ether is wholly irrelevant to the question, so that if our analogies break down, it is not on the question of the reality of the ether. Leaving analogies behind, we proceed to discuss the real physical problem at issue.'' This is taken from Sir James Jeans' ''Report on Radiation and the Quantum Theory'' (1924), page 5, being the concluding words of the introduction.

Lodge is a staunch believer in the ether and it is to be hoped that it will be said: Lodge was quite correct in his general belief. Such an advance as this need not, however, disturb the relativity principles which seem so well established by experiment. Einstein himself would no doubt subscribe to the idea of an ether, if he has not already done so; but at present it can not be definitely defined in a way satisfactory to the lay mind, or even to the mind of the physicist, so it is of necessity left out of the picture. In fact, it is not needed in wireless work. It becomes a meaningless label, and hence an inexact one from this point of view.

As in many advanced matters of physics, the words are not categorically definition-words, but expressions of speech which convey the state of affairs as understood by the context and the state of the art. The subject of the verb may even be truly missing, as in the case of the ether being the subject of the verb undulate, to cite an oft-repeated observation, but an inexactitude that is understood within the limits prescribed.

### Definitions

It will be seen that in order to maintain a status of exactness the ultimate definitions have to be avoided. If one sets to work and invents definitions of matters about which too little is known, as research progresses one is apt to be faced with terminological inexactitudes of one's own making. For this reason definitions are not as a rule regarded with special favor. It is true, however, that the definition could be so drawn up as to give satisfaction to all concerned; but it is difficult to do this, and such elaborate definitions would involve statements tantamount in part to no definition at all. Some facetious person might then say: "This is the tune of our catch, played by the picture of Nobody" —to borrow a quotation used by Sir Arthur Eddington in his "The Nature of the Physical World," page 292, where he discusses reality.

### The Radiation Dilemma

Coming now to the physics of the atom involving the scheme of affairs in giving out radiation when excited, there are some very perplexing matters that at once label the situation as hopelessly inexact; for, according to one established wave theory of light, correct answers are given to many optical phenomena implying an exact theory with mathematical computations exact to the finest measurement; but, when another set of optical experiments, relating more particularly to the origin of the light, that is to say, its quantum nature, are examined, it is found that the above theory does not fit the cases and the light has to be treated as made up of parcels or atoms of radiation; and here too exact results come out of the mathematical analysis, all according to the well-established laws or rules of the quantum theory.

Sometimes this dilemma is expressed as being continuity *versus* discontinuity, but perhaps it might be better to say spreading *versus* convergence. In further traversing some familiar ground, in the photoelectric effect the radiation seems of its own accord selectively to converge on an individual atom and cause an electron to fly out of the said atom; and this—the convergence without a lens being used—is opposed to experimental data, since no such convergence can be optically demonstrated. It has in a sense to be imagined and yet it is known that light inherently spreads.

This can be explained by assuming that radiation in space has no particular quantum property in itself except that it is like a host of radial lines emanating from a number of centers in the light source. Where these lines meet at one spot in sufficient number, whilst of the proper frequency, they make up the

quantum determined by the atom and then the electron is ejected with this energy. It is better, however, to consider this problem from the point of view of recent theories, as these solve other problems as well.[2]

### Several New Theories

A set of powerful theories have grown into formidable proportions; but they seem to be equivalent, or they merge on common ground. The upshot of it all is that matter, the atom and the electron are fundamentally waves. Everything in the end analysis reduces to waves, the wave-equations satisfying the experimental facts, so that a wide variety of phenomena are amenable to this particular treatment, which in some phases is highly symbolic and involves mathematical processes of the most far-reaching kind. The principal names associated with this advanced development are: L. de Broglie, Dirac, Heisenberg and Schrödinger.

Yet the meanings attached to the mathematical operations become for the most part difficult or impossible of definition in terms of known phenomena. It is as if coarse phenomena could be described in terms of the same phenomena on a smaller scale until a state of affairs is reached when this type of description utterly fails and recourse to pure mathematics becomes necessary to carry on the analytical process. Then when the mathematical work is resolved back, as it were, the direction of the process of definition becomes reversed, and comparatively large-scale phenomena are definable in the new ultimate terms of the small-scale phenomena; hence the seeming incongruity; still, one sufficiently equipped is tempted to throw overboard all the old-time notions of things and to work with the newer ideas, which are largely equations and symbols. It all works. Yet some of the meanings attached to mathematical operations become impossible of pictorial definition. Thus, in the pursuit of exactitude the word-pictures have to be abandoned. The tune played by the mathematician is on mental instruments, but the reality it stands for has no corresponding picture, which brings the subject back to the "tune of the catch played by the picture of Nobody."

### Science Too Exact!

The trouble with the advanced method of the kind herein discussed is that today it is too exact. The precise tools of the mathematician have been fitted to the secret locks of nature and these when unlocked reveal the most extraordinary state of mechanism, if it may be so called, that is quite beyond the hope of man's interpretation in terms of common things or even in terms of uncommon things. What is going to be done? This is no doubt a question latent in the minds of some advanced workers. It is getting too complicated for words, and when it all reduces to the most elaborate mathematics, what then? It is like expressing all the curves and arrangements of letters on this page mathematically. We need, perhaps, less exact science in fact. A science that is willing to forego some of the precision now attained and one which will give a working picture of things. Shall the

[2] "The fundamental law of quantum-dynamics, that radiant energy is emitted and absorbed only in complete quanta, is no longer interpreted as meaning that the ether can carry radiant energy only in complete quanta, but that matter can deliver or absorb radiant energy only by complete quanta. It is matter, and not ether or radiant energy, which proves to be different from what we had thought." This statement appears in Jeans' report (cited in the previous footnote), page 80. Since this was written new experimental facts have perhaps modified the view just expressed, as the space devoid of matter may carry light quanta as more or less isolated units; but this interpretation may be at fault, so that Jeans' statement may still hold true. It is only by studying the experimental data and theories referred to in the next section that this statement can be reconciled, and then perhaps only with difficulty.

mathematician have to step aside for the artist who does things by an art that is not quite so difficult of mastery? Moreover, the artist's picture complete in the minutest detail appeals with integrated strength, whereas the mathematical conceptions are more like a futurist nightmare when attempts are made to translate them into pictorial effect—the tune is played by the picture of nobody.

### The Principle of Indeterminacy

Notwithstanding, out of all this complex of mathematical analysis some comparatively simple ideas are emerging, and it is perhaps these that will save the situation, and the immediately-preceding statements will then be beside the point. Great interest is now aroused in the principle of indeterminacy of Heisenberg. It appears that in the search for truth underlying the movements of the electron in connection with the atomic state of matter, the precise position of the electron and its precise velocity can not be determined simultaneously. The uncertainty is axiomatic, and this calls to mind the uncertainty of the behavior of a given atom in throwing off a part of its substance and becoming an atom of another element which is the basis of radioactivity. Average results can be predicted, but the behavior of the individual is uncertain. The laws of the radioactive atoms are known, except that the particular atom that is going to disintegrate next is as uncertain as the drawing of a lucky horse in the Dublin Sweepstake.[3]

### Science Terribly Exacting

In preface to the above it is believed that in mass operations statistical laws apply with great exactitude, but when getting down to individuals the laws appear chaotic. There is a human element in this behavior, as when the innermost workings of nature—even in inorganic chemistry and physics—are studied they appear to be quite erratic, just as the movement of a Mr. Jones or a Mr. Smith at a given instant can not be predetermined. Their average or daily movements can be accounted for or ascertained beforehand, but just what Mr. Jones is going to do the next minute no one can say. In the Scotland Yard of science the principle of the alibi is indeterminate and has to be abandoned.

Drawing a lesson from this, exactitude leads to inexactitude, so that coming back to Lord Birkenhead's dictum it should perhaps be written: Science is not exact but terribly exacting. It must be known where the inexactitude lies and such knowledge involves research of the most exacting kind. Eddington even goes so far as to intimate that the application of a law of inexactitude may be productive of far-reaching results. To discover new principles from very exact experimental work coupled with mathematical analysis are achievements that fully justify the work and point even to greater advances in fundamental knowledge being possible in the immediate future.

[3] There is one feature bearing on the above that needs consideration. The contents of an egg before it is placed in an incubator does not reveal the potential structures of a chicken, yet when it is subjected to warmth, which is radiation, these structures develop systematically and a chicken is evolved according to type. The egg is therefore an example of determinism; and might not one say that the atom, being less familiarly known than the egg, is also an example of determinism? Or, to state it another way, the medium of the egg and the medium of the atom have in common the property of storing in their structures potential qualities, so that their behavior is deterministic. The answer to this is probably that, whereas, we do not know the so-called egg-substance-structure in a fundamental sense, we do know something about the structure of the atom fundamentally, and it is this knowledge that has given rise to the principle of indeterminacy. Moreover, in the atom the indeterminable quantity is a single entity, for example, the electron; whereas, in the egg the determinism applies to large molecular groups, just as it does with atoms in mass formation or in large numbers, as stated above. The egg can not therefore serve as a criterion for judging the doctrine of indeterminacy.

# CONCERNING THREE-EYED FISHES

By FRANK E. FIRTH

U. S. BUREAU OF FISHERIES

IN the November-December issue of *The American Naturalist*, Vol. lxii, 1928, Dr. E. W. Gudger, of the American Museum of Natural History, New York City, carefully described certain known instances of the occurrence of three-eyed embryos. He also described the case of an adult haddock with three eyes, which seems quite a questionable record. Although several photographs of it are shown, the study of the other occurrences seemed necessary. After exhausting the literature on this subject, it was shown that three-eyed forms occur as embryos only, with the exception of one instance. In this, however, the author, Dr. Meek, obtained the confession of the party who so cleverly "faked" the specimen.

Dr. Gudger painstakingly, cleverly and rather accurately deduced that the specimen in question was no less than a skilfully prepared "fake." Although he was without proof at the time he wrote, he was right.

A year after publication of the article mentioned above, Dr. Gudger's attention was called to the "Ruminations of a Codfish Forker," in *The Fishermen's Own Book*,[1] where the following statement was printed:

> Seems there was a three-eyed haddock brought in at T-Wharf. This don't impress me so much. I once had a buddy on one of these schooners, and he told me how he slipped up on a feller once, was sitting off by himself on the trip home. This old feller was a great one for whittling, real handy with a knife. Well, he was working on the head of a haddock, real careful like, when he got through, he brought a fish eye out of his pocket and slipped it in the hole, just as neat as you please. Never saying a word, he drops the three-eyed haddock back with the other fish, and the next day, folk was coming from far and wide down to the fish pier to see the latest wonder of the world, the three-eyed haddock.

Thus was substantiated the conclusions arrived at by Dr. Gudger at that time after a study of the photographs and literature. Accordingly this latest exposé was published in the *Annals and Magazine of Natural History*.[2]

During the summer of 1930, while stationed at the Boston Fish Pier, Boston, Massachusetts, on a mackerel investigation, I chanced one day to bring up

[1] New York, Vol. viii, No. 4, p. 28, 1928.

[2] London, Ser. 10, vol. vi, p. 41, July, 1930.

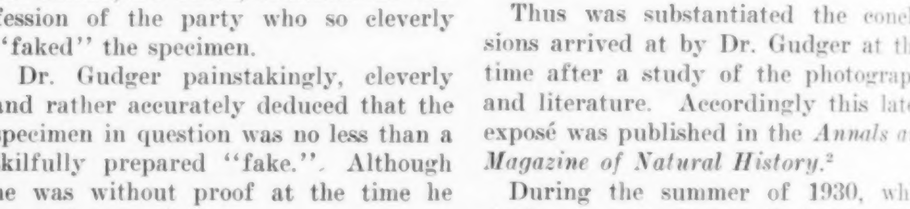


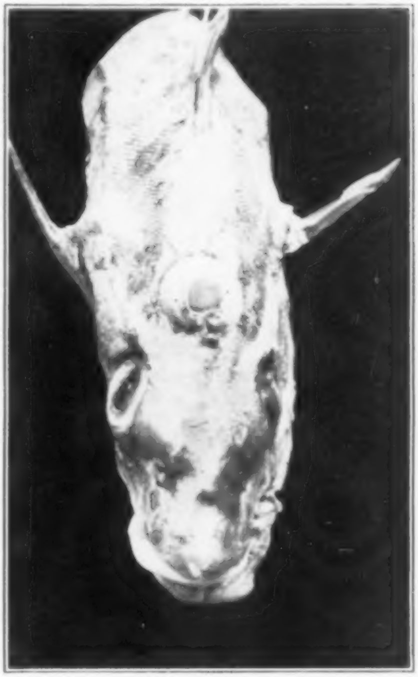
FIG. 1. A THREE-EYED TROUT EMBRYO, LENGTH ABOUT 20 MM. THIS IS A SPECIMEN OF WHAT EVIDENTLY BEGAN AS A TWO-HEADED FISH, THE THIRD-EYE BEING FORMED BY THE FUSION OF THE TWO INNER EYES. (After Gemmill, 1912).

the subject of deformities and irregularities so often encountered in fishes. In the group was one of the real "old-timers" of the pier, who recalled the incident of the three-eyed haddock some years ago and told how certain scientific men were at a loss to explain its cause. Then, with a mirthful gleam in his eyes, he confessedly continued: "I don't know what prompted me to do it, but on the way to the store with a cart of fish [haddock] just received from a vessel, I stopped, removed a haddock and cut a hole in the middle of the head of it. Next, I removed an eye from another fish, leaving a long stalk on it [the optic nerve] and forced it into the cut hole of the first specimen. Placing it in the top layers of the fish in the cart I continued on to the store. Within a very short time it was 'discovered' and you know the rest."

Thus, after a few years of doubt, we have the truth and necessary proof of the occurrence of three-eyed haddock, not fashioned by nature but rather by man.

The first intimation of the discovery of the so-called three-eyed haddock was in the *New York Herald-Tribune*, October 9, 1927, when the fish was described and recorded. Due to the great similarity in the methods each man employed in creating these fish, it is quite probable that each one was truthful but that only one ever got into the newspapers.

In connection with this there is another very interesting "origin" of a similar abnormality. This too happens to be by an English scientific man, but it is *not* Dr. Meek, whose case has been mentioned previously. It concerns a Dover or black sole, and was published



—*Wide World*

FIG. 2. A DORSAL VIEW OF THE HEAD OF THE THREE-EYED ADULT HADDOCK, THE FISH CONCERNED IN THIS ARTICLE. THE SHARP DIFFERENTIATION OF THE SCALY SKIN SURROUNDING THE CENTRAL EYE IS PLAINLY SHOWN HERE.

in *Fishing News*, Aberdeen, Scotland, July 19, 1930, as follows:

> An English scientist had a friend on board a trawler who used to take unusual specimens ashore to him. In payment for these specimens he (the fisherman) was always given a drink. One day the trawler friend had no specimens and he was real thirsty, so he slit a small hole between the two eyes of a witch sole and slipped a haddock eye into it, and behold a three-eyed witch. The trawler friend got his drink all right, and the scientist had such a rare specimen that he wrote a thesis on it. He discovered after his paper had been printed and circulated that his friend was a gay dog.

And there is yet to be found a genuine three-eyed adult fish.

PROFESSOR ELIHU THOMSON

Whose eightieth birthday was celebrated at the Massachusetts Institute of Technology on March 29 by a conference, a historical exhibit and a testimonial dinner. At the conference papers were read by Professor John C. Slater and Dr. Karl K. Darrow, and by President Karl T. Compton, who made an address on the "Significance of Professor Thomson's Work in the Development of Electrical Engineering." At the dinner the speakers included Governor Joseph B. Ely, Mr. George B. Cortleyou, Mr. H. P. Charlesworth, Dr. Harvey W. Cushing, Dr. Vannevar Bush, Dr. Dugald C. Jackson, Dr. Howard McClenahan, Dr. E. W. Rice, Jr., and Professor Thomson.

# THE PROGRESS OF SCIENCE

## THE CONTRIBUTIONS OF PROFESSOR THOMSON TO ELECTRICAL ENGINEERING

PROFESSOR ELIHU THOMSON, scientist, inventor and dean of living electrical engineers, was eighty years old on March 29, 1933. During his lifetime, rich in accomplishments and inventions, has come the development of the electrical industry of which he is one of the great pioneers—the last of the American "Big Four" of electricity, the other three being Thomas A. Edison, Charles F. Brush and James J. Wood. At eighty Professor Thomson is still active and alert and devotes long hours to the direction of the important research problems in the laboratory of the General Electric Company, at Lynn, which bears his name. In the years which he has given to electrical science—more than half a century—Professor Thomson has been granted more than 700 patents in the United States and he holds many foreign patents as well.

Elihu Thomson was born in Manchester, England, and came with his parents to this country when he was about five years old. The boy began his education in Philadelphia. From his father, an engineer and skilful mechanic, Dr. Thomson inherited his ability in the mechanics arts and the never-to-be-satisfied curiosity out of which have come many of his great contributions to science and engineering.

Already, as a boy, he began making models of physical apparatus. In his office he still has a frictional electrical machine which he made at eleven years of age and the principal part of which was an old wine bottle which could be rotated by a crank. It is told that he demonstrated the machine to his father, who was not particularly impressed by the tiny sparks which it produced. Elihu Thomson, however, desired to show his father that his machine after all was not merely a plaything. So he used it to charge several Leyden jars. He then repeated his former demonstration to his father with such effectiveness as almost to flatten him by the shock.

Upon having completed his education, Elihu Thomson became connected with the Boys' Central High School in Philadelphia and at the age of twenty-three was made a full professor of chemistry and mechanics. He was a beloved lecturer and had the ability to keep his students' interest fully. It was during this period that he also gave a series of scientific lectures at the Franklin Institute in Philadelphia, holding his audiences fascinated by his experiments in electricity. His interest in these years was centering definitely in the field of electricity, and it was in 1876 that he demonstrated his first dynamo at the Franklin Institute.

With his colleague, Professor E. J. Houston, he continued the development of dynamos, and the one built in 1879 may be said to have been the basis of the arc-lighting system which became known as the Thomson-Houston system. In 1880, however, his association with Professor Houston ended and he moved to New Britain, Connecticut, where his patents for a time were exploited by the American Electric Company. Subsequently the business was moved to Lynn, Massachusetts, under the name of the Thomson-Houston Electric Company, which later (with the Edison General Electric Company) became the General Electric Company.

Professor Thomson's inventions and contributions to the development of electrical engineering have been many and varied. It would carry us too far afield to attempt to mention them all. The most important ones, however, are his developments of the dynamo with its automatic regulator and its commutator-spark-prevention device, usually termed

PROFESSOR THOMSON AND DR. E. W. RICE, JR.

WITH THE ELECTRIC DYNAMO BUILT SIXTY YEARS AGO. DR. RICE WAS A PUPIL OF DR. THOMSON AT THE CENTRAL HIGH SCHOOL OF PHILADELPHIA MORE THAN FIFTY YEARS AGO, AND THE TWO HAVE SUBSEQUENTLY BEEN CLOSELY ASSOCIATED IN THE WORK OF THE GENERAL ELECTRIC COMPANY.

his air-blast mechanism. The latter works on the principle of injecting a stream of deionized air at the instant the current passes through zero, thus making it impossible for the incipient alternating-current arc to become established. The principle which he here introduced is of fundamental importance and is indeed to-day incorporated in the design of large circuit breakers.

Another of his important electrical developments is that of the constant-current transformer, which made it possible to supply a series circuit containing alternating-current arc lights with a constant current, independent of the number of arcs which were used. Since most of the lighting at the time was done by arc lamps, it is not surprising that Professor Thomson also designed and patented a number of these, making their automatic operation highly reliable.

Again, another electrical field where Professor Thomson has done outstanding work is that relating to metering of electric energy. He developed several types of recording watt-meters, or watthour meters, as they usually are called to-day. His designs at the present time practically monopolize the world's market. His meters are used wherever electricity is used, and it is said that around thirty million Thomson watthour meters are to-day in actual operation.

Although most of his work has been in connection with electrical devices, his contributions in the mechanical field have also been numerous. Thus in the years 1877 to 1881, jointly with his colleague, Professor Houston, he invented and patented the continuous centrifugal cream separator. This was a device ap-

plicable to the separation of substances of different densities, and has come into universal use in creameries as well as in the laboratory and elsewhere for centrifuging mixtures which it is desired to separate.

Another mechanical development in which Professor Thomson has been deeply interested is that of steam generation and its subsequent utilization in high-efficiency engines. In 1901 he obtained a patent for a "vapor generator" which was virtually a steam boiler and an oil burner combined into a very moderate-sized structure in relation to the output. In developing this boiler Professor Thomson had its application to automobiles in mind, but evidently it might be useful for many other purposes. One important feature in this connection is its ability to relight three hours after extinguishment simply by turning on the fuel supply. It seems, however, that his pioneer work in this particular field has never received the attention which it actually deserved.

Hand in hand with his work on the above-mentioned boiler was his development of a high-efficiency engine. In his patent of 1903 this is termed the "fluid-pressure" engine. It was a non-condensing reciprocating engine involving a somewhat novel principle in that the steam was permitted to flow in one direction only—from the intake to the exhaust—never turning back to come once more in contact with the heated surfaces. It gave remarkably good results. No doubt Professor Thomson here laid down a new and important principle for engine design. Engines built on this principle are now generally known as "uniflow" engines and have been manufactured and used to a considerable extent, especially in Germany.

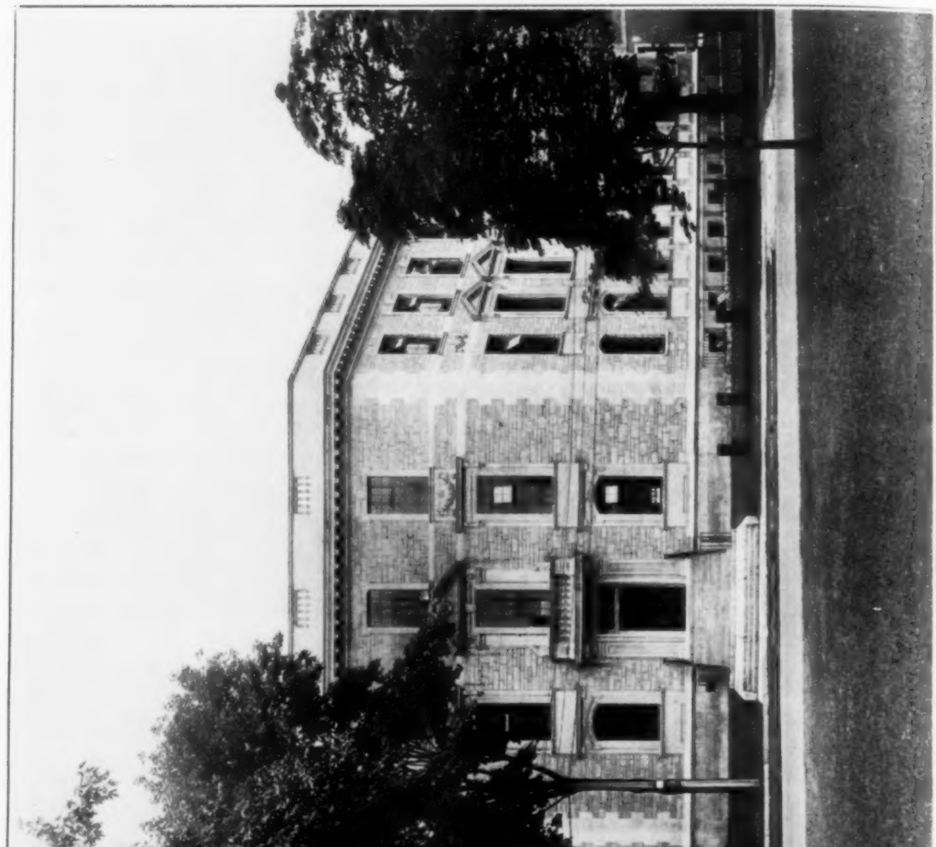
It would be possible to go on elaborating on his electrical, mechanical and other inventions, but evidently space does not permit. Let it suffice to call attention to his work in a somewhat special field, namely, that of the manufacture and application of fused quartz. His early interest in optical instruments led to his intensive study and experimentation in this field, and many patents have been taken out by him since 1902. The methods perfected under his direction have proved markedly successful and permit the construction of quartz apparatus in size and quality hitherto unapproached. Its principal applications are optical lenses and mirrors, windows for deep-sea diving bells and for use as a transmission glass for ultraviolet light in hospitals and special lamps.

Professor Thomson possesses the constructive powers of the inventor, the thoroughness and soundness of a man of science and the kindly balance of the ideal philosopher, teacher and friend. This remarkable combination of qualities has endeared him to all with whom he has come in contact. Throughout his life he has set an example by which the younger generation may well profit.

## THE NEW BOTANY BUILDING AND PLANT HOUSES OF THE UNIVERSITY OF TORONTO

THE botanical laboratories and plant houses of the University of Toronto, the provincial university of Ontario, were formally opened and presented to the university on June 8, 1932, by the Prime Minister, who is also Minister of Education of the Province of Ontario, the Honorable George S. Henry. The first work, on the excavation, had been begun about fifteen months previously.

This new unit of the university's equipment is situated on the west side of the entrance to Queen's Park at the southeast corner of the university cam-



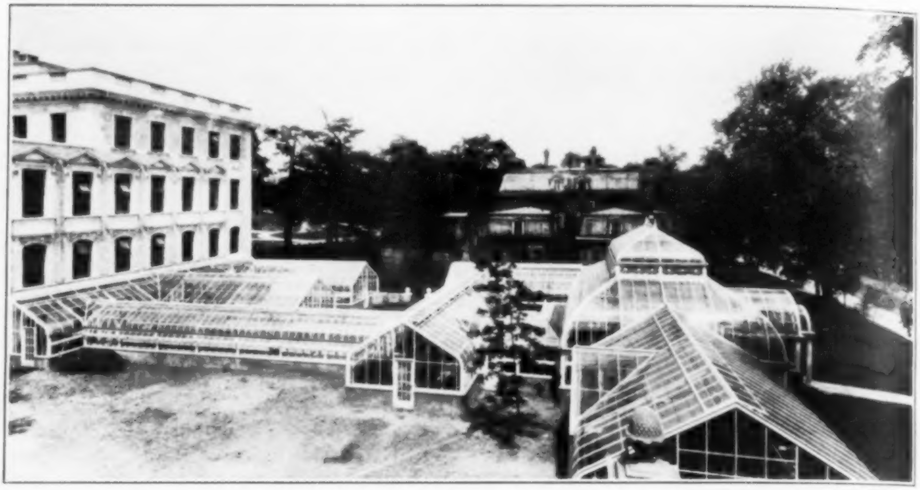
BOTANY BUILDING AND PLANT HOUSES FROM QUEEN'S PARK

pus, the building facing the Ontario Legislative Buildings in the park to the north and the plant houses facing south on College Street. The building is a four-story Georgian structure, with a total floor space of 42,600 square feet. It is in the form of a hollow square open at one corner and is constructed of Ontario limestone—Credit Valley, with Queenston trim. The relief decoration of important panels is of botanical character—designed from familiar local plants, pine, oak, water lily, etc.

The main entrance opens into a small octagonal foyer with walls of Tyndall limestone, which is flecked with buff. It has a parquet floor of black, light gray and white marble. The halls have a three-quarter facing of buff brick and where traffic is not concentrated, are sufficiently wide to accommodate wall cases for the display of special class material. The trim and furnishings throughout are of birch and pine in walnut finish. Two fireproof stairways are located at opposite corners—one at the northwest and the other at the southeast. They open on the quad and serve ordinarily as extra entrances and exits for elementary and advanced students, respectively.

The main entrance for students is at the west side of the west wing, nearest the other university buildings. In the lowest story of this wing at opposite sides of the entrance hall are the large cloak-rooms for men and women and the lecture theater with seating for 180 students. This has an adjacent chart room and is two stories high. There is no gallery at present, but one can be added with entrance on the next floor, which will increase the accommodation by about sixty. On the main floor in this wing there is a lecture room for 60 students; on the second floor, a large laboratory with accommodation for 150, with adjacent preparation and supply rooms; and on the third floor a smaller laboratory to accommodate seventy students, also preparation, storage and photographic rooms. These general laboratories are fitted with unit tables accommodating eight students—four at a side. The tables are acid-proof and are supplied with daylight microscope lamps (two to a table), gas and individual microscope lockers and supply drawers. There are five supply drawers in a tier at one side of each work place and two microscope lockers in a tier at the other side. The student of each class is given a key for one of the microscope lockers and one of the supply drawers. Each student has thus beside him all the equipment he needs and does not disturb the class in getting it. In the large laboratory, which is used for bacteriology as well as elementary morphological work, running water is also provided for each student. On all floors this west wing is separated from the remainder of the building by swinging doors in the corridor just east of the stairway, so that the noise and confusion of the coming and going of large elementary classes is restricted to this part.

The remainder of the building contains laboratories for advanced classes and private research, offices of the staff, library, herbaria and research rooms for graduate students, as well as the necessary workrooms, storerooms and machine rooms. The rooms for graduate students face the quad on all floors. Each has two windows and duplicate equipment. The main part of the lowest story is given over to the work of plant pathology under the direction of Professor D. L. Bailey; the south part to the potting rooms and office of the horticulturist. On the first floor, to the west of the main entrance, are laboratories for cytology; to the south, the laboratories for plant physiology, under Professor G. H. Duff. The south block on this floor contains the living apartments of the horticulturist. On the second floor, above the main entrance, is the library with the



GENERAL VIEW OF PLANT HOUSES

CORRIDOR HOUSE ON LEFT GIVING DIRECT CONNECTION WITH BUILDING ON LOWEST FLOOR LEVEL.

seminar room to the west of it; to the south, laboratories for forest pathology, and the staff room and office as well as private laboratory of the head of the department, Professor R. B. Thomson, and adjoining these in the south wing are the laboratory and the storerooms for work in morphology and anatomy. On the third floor, above the main entrance, is the herbarium of flowering plants; to the west are the seed laboratories under Professor H. B. Sifton, and to the south the mycology laboratories and herbaria under Professor H. S. Jackson.

The plant houses, which lie to the south, are attached to the building by a glass corridor extending the length of the south wing. As the floor of this corridor is on the same level as that of the houses and the ground floor of the main building, plants may be readily moved from one to the other, without being subjected to change of temperature, and by means of the elevator taken to any desired floor.

Opening on the east end of the corridor are the houses for plant physiology and immediately west those for plant pathology. Next comes a passageway house in which propagation work is carried on. It connects the main group of houses with the corridor. This group comprises a number of individual houses with special temperature and moisture controls, suited to a variety of plant types. A palm or tropical house occupies the center of the southern range, to the west of which is the fern house and to the east the cactus or desert house. The part north of the latter is for plants of intermediate temperature requirements, and directly behind the palm house is one for cool temperature plants.

The houses cover an area of 6,476 square feet and are heated with hot water. This in turn is heated by steam from the central heating plant. In case of accident an oil-burning furnace cuts in automatically and an alarm sounds in the horticulturist's quarters. A well provides unchlorinated water and provision has also been made for the collection and storage of rain water.

One pleasant fact remains to be recorded. The total cost did not exceed the estimate, a little over \$500,000. There were at least two factors responsible for this. Plans had been in preparation off and on for twenty years, so

that there was practically no alteration necessary when the building was under way. In the second place, the cost of materials and labor lowered considerably between the time the appropriation was made and the actual time of spending the money.

R. B. THOMSON
PROFESSOR OF BOTANY,
UNIVERSITY OF TORONTO

## THE EFFECT OF SUNLIGHT ON THE GROWTH OF FLOWERS

CLASSIC myth had the Greek sun-god, Phoebus, turn himself into a shower of gold, to visit one of the numerous lovely ladies of whom he was enamored, when she was locked up in an inaccessible tower. So to-day the sun is able to visit the hosts of delicate woodland flowers that live only through his favors, by showering himself through the interlaced bars of the as yet unleaved tree branches.

It seems a trifle paradoxical that the flowers of the early spring woods should be so much like the flowers one finds in the semi-arid lands of the Southwest and the Rocky Mountains, yet such is the case. Some of them are of the same genera: violets, trout-lilies, buttercups, anemones, spring beauties, and many others. And even where they are not fairly close relatives, there are astonishing resemblances in general habit of growth.

The solution to the paradox is to be found in the fact that before the leaves are on the trees, the ground under them is not, properly speaking, in the woods. It is at least halfway in the windy, sunny open, subject to much the same illumination and the same evaporation rates as the prairie alongside or the chaparral a thousand miles away. Only when the leafy canopy has closed itself, excluding the warming sun and materially cutting down the force of the drying breeze, does the forest become properly a forest to the trees that grow underneath. Then it is that the spring flora—geraniums, phloxes, bellworts, hepaticas and all the rest—give way to the much reduced number of flowers that will consent to blossom in the deep shade of the summer woods.

This characterization of the spring woods as really touched with the tang of the desert is no mere impression. The difference between the woods of May and the woods of July has been scientifically measured. Several years ago sets of instruments for measuring the evaporation rate of water were placed in a typical strip of midwestern woodland along the bluffs of the Illinois River, and kept in operation from the first of May until nearly the end of September. The evaporation rate in July was high, as might have been expected. But a result that was not expected at all was that in the first week in May, when the leaves had not yet covered the oak trees, the evaporation rate was still higher!

Violets, buttercups, spring beauties, trilliums, Jack-in-the-Pulpit, Solomon's seal, May-apple, bloodroot, blue-eyed grass, Dutchman's breeches—these and a host of other lovely blossoms we instantly hail as gifts of spring. With hardly an exception, the flowers that star the woods just before and after Easter were prepared for our present delight during the summer that is past. They were paid for out of savings thriftily laid by during a former time of abundance.

Examine the underground parts of any one of the flowers named, or of almost any other spring flower you can find, and you will find a thickened root or rootstock or bulb or corm, or some other form of "storage organ," filled with starch like a potato or with sugar like an onion. This was formed out of the surplus food manufactured by the plant last summer—sometimes during several summers—when no flowers were in sight or in immediate prospect. All

winter through it lay under ground, compact energy of the sun fixed and hidden away, ready to be liquidated when the returning warmth and light of that same sun should give the word this spring.

Summer flowers, many of them, will be different. There will, of course, be plenty of perennials, long-lived and food-storing plants among them, but summer plants also include many annuals, plants that grow during one season from seed, form seed for the next year, and then die when frost comes. The longer time they have before their flowers become mature gives opportunity for this short life cycle to complete itself and still leaves next year's generation provided for in the scattered seeds.

Of course, the perennials par excellence are the trees, for these store their food in the exceedingly tough and long-lived wood of trunk and roots. It is for this reason, presumably, that most trees —alder and willow, maple and oak, dogwood and redbud, magnolia and tulip-tree and a host of others—are as truly spring flowers as are violets and buttercups.

March sunshine, and even February sunshine, have as much to do with bringing forth May flowers as have the traditional April showers. And it is not merely the sun's part in thawing the snow and ice of winter, nor his gifts of food through the sugar-making factories in the leaves, that bring about the miracle of bloom in spring woods and fields, but the long-neglected astronomical fact that in spring each day is a little longer than the day before.

For uncounted centuries people had seen the flowers spring up as the sun returned northward after his winter retreat. The connection of increased sunlight with the pleasures of spring had not escaped even the oldest of peoples. From the Nile to the Baltic, from India to Yucatan, men made a god of the sun and invented myths of spring, some of them most poetic and beautiful.

But it was not until a short time ago that two scientists of the U. S. Department of Agriculture, Dr. W. W. Garner and H. A. Allard, discovered that the changing length of day is a potent control over the blossoming time of plants. They put numbers of different kinds of flowers and vegetables into a greenhouse equipped with shades and electric lights, so that they could give them a wholly artificial length of "day," making it at will longer or shorter than the natural day. They soon found that plants whose season of bloom came before midsummer were stimulated into flower production by increasing the light-period a little each day, whereas plants of naturally late flowering habits could be brought into bloom by daily shortenings of light. Typical "long-day" plants are crocus, hyacinth, iris, columbine, lily of the valley—all spring flowers. "Short-day" flowers include goldenrod, aster, chrysanthemum, sunflower—flowers of autumn and late summer.

Since these pioneer workers carried on their experiments, many other botanists, as well as commercial florists, have repeated the work and elaborated on it, so that greenhouses are hardly accounted complete unless they have their batteries of electric lights to make artificial lengthening of daylight possible. But in our admiration of the ingenuity of human gardeners, we must not lose sight of the fact that the first to use this method of bringing flowers into bloom by changing the length of day was the ruler of day itself, the sun.

Frank Thone

Science Service